Department of Defense
Fiscal Year (FY) 2020 Budget Estimates

March 2019

Navy

Justification Book Volume 1 of 5

Research, Development, Test & Evaluation, Navy

Budget Activities 1, 2, and 3

The estimated cost of this report for the Department of the Navy (DON) is $17,771.

The estimated total cost for supporting the DON budget justification material is approximately $1,803,116 for the 2019 fiscal year. This includes $81,351 in supplies and $1,721,765 in labor.

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Department of Defense Appropriations Act, 2020

Research, Development, Test and Evaluation, Navy

For expenses necessary for basic and applied scientific research, development, test and evaluation, including maintenance, rehabilitation, lease, and operation of facilities and equipment, $20,434,909,000 to remain available for obligation until September 30, 2021.

FY 2020 Overseas Contingency Operations funding can be separated into the following categories:

OCO for Direct War Costs ($37,000,000): OCO for Direct War costs are those combat or direct combat support costs that will not continue to be expended once combat operations end at major contingency locations.

OCO for Enduring Requirements ($127,410,000): OCO for Enduring Requirements are enduring in-theater and in-CONUS costs that will likely remain after combat operations cease, and have previously been funded in OCO.

OCO for Base Requirements ($0): OCO for Base Requirements is OCO funding for base budget requirements in support of the National Defense Strategy. The Budget requests these funds in OCO to comply with the base budget defense caps included in the Budget Control Act of 2011.

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Department of Defense
FY 2020 President's Budget
Exhibit R-1 FY 2020 President's Budget
Total Obligational Authority
(Dollars in Thousands)

Appropriation	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted
Research, Development, Test & Eval, Navy	18,465,332	18,490,002	167,812	18,657,814
Total Research, Development, Test & Evaluation	18,465,332	18,490,002	167,812	18,657,814

Department of Defense
FY 2020 President's Budget
Exhibit R-1 FY 2020 President's Budget
Total Obligational Authority
(Dollars in Thousands)

Appropriation	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)
Research, Development, Test & Eval, Navy	20,270,499		164,410	164,410	20,434,909
Total Research, Development, Test & Evaluation	20,270,499		164,410	164,410	20,434,909

Department of Defense
FY 2020 President's Budget
Exhibit R-1 FY 2020 President's Budget
Total Obligational Authority
(Dollars in Thousands)

Summary Recap of Budget Activities	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted
Basic Research	604,634	679,772		679,772
Applied Research	975,419	1,018,795		1,018,795
Advanced Technology Development	900,071	851,710		851,710
Advanced Component Development & Prototypes	4,210,640	4,139,479	33,300	4,172,779
System Development & Demonstration	6,037,909	5,863,466	1,100	5,864,566
Management Support	1,388,936	1,023,070		1,023,070
Operational Systems Development	4,347,723	4,913,710	133,412	5,047,122
Total Research, Development, Test & Evaluation	18,465,332	18,490,002	167,812	18,657,814

Summary Recap of FYDP Programs				
Strategic Forces	192,820	240,310		240,310
General Purpose Forces	1,514,837	1,914,231	16,130	1,930,361
Intelligence and Communications	816,404	608,772		608,772
Research and Development	13,991,927	13,937,905	34,400	13,972,305
Central Supply and Maintenance	40,084	73,844		73,844
Administration and Associated Activities	1,820	1,579		1,579
Space	49,738	42,858		42,858
Classified Programs	1,857,702	1,670,503	117,282	1,787,785
Total Research, Development, Test & Evaluation	18,465,332	18,490,002	167,812	18,657,814

Department of Defense
FY 2020 President's Budget
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Total Obligational Authority
(Dollars in Thousands)

Summary Recap of Budget Activities	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)
Basic Research	605,978				605,978
Applied Research	936,453				936,453
Advanced Technology Development	742,210				742,210
Advanced Component Development & Prototypes	5,559,062		40,006	40,006	5,599,068
System Development & Demonstration	6,332,033		1,122	1,122	6,333,155
Management Support	990,464				990,464
Operational Systems Development	5,104,299		123,282	123,282	5,227,581
Total Research, Development, Test & Evaluation	20,270,499		164,410	164,410	20,434,909
Summary Recap of FYDP Programs					
Strategic Forces	239,019				239,019
General Purpose Forces	1,835,959		15,000	15,000	1,850,959
Intelligence and Communications	692,089				692,089
Research and Development	15,828,006		41,128	41,128	15,869,134
Central Supply and Maintenance	44,961				44,961
Administration and Associated Activities	1,460				1,460
Space	15,868				15,868
Classified Programs	1,613,137		108,282	108,282	1,721,419
Total Research, Development, Test & Evaluation	20,270,499		164,410	164,410	20,434,909

Department of the Navy
FY 2020 President's Budget
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Total Obligational Authority
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Summary Recap of Budget Activities	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted
Basic Research	604,634	679,772		679,772
Applied Research	975,419	1,018,795		1,018,795
Advanced Technology Development	900,071	851,710		851,710
Advanced Component Development & Prototypes	4,210,640	4,139,479	33,300	4,172,779
System Development & Demonstration	6,037,909	5,863,466	1,100	5,864,566
Management Support	1,388,936	1,023,070		1,023,070
Operational Systems Development	4,347,723	4,913,710	133,412	5,047,122
Total Research, Development, Test & Evaluation	18,465,332	18,490,002	167,812	18,657,814

Summary Recap of FYDP Programs				
Strategic Forces	192,820	240,310		240,310
General Purpose Forces	1,514,837	1,914,231	16,130	1,930,361
Intelligence and Communications	816,404	608,772		608,772
Research and Development	13,991,927	13,937,905	34,400	13,972,305
Central Supply and Maintenance	40,084	73,844		73,844
Administration and Associated Activities	1,820	1,579		1,579
Space	49,738	42,858		42,858
Classified Programs	1,857,702	1,670,503	117,282	1,787,785
Total Research, Development, Test & Evaluation	18,465,332	18,490,002	167,812	18,657,814

Department of the Navy
FY 2020 President's Budget
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Summary Recap of Budget Activities	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)
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Applied Research	936,453				936,453
Advanced Technology Development	742,210				742,210
Advanced Component Development & Prototypes	5,559,062		40,006	40,006	5,599,068
System Development & Demonstration	6,332,033		1,122	1,122	6,333,155
Management Support	990,464				990,464
Operational Systems Development	5,104,299		123,282	123,282	5,227,581
Total Research, Development, Test & Evaluation	20,270,499		164,410	164,410	20,434,909
Summary Recap of FYDP Programs					
Strategic Forces	239,019				239,019
General Purpose Forces	1,835,959		15,000	15,000	1,850,959
Intelligence and Communications	692,089				692,089
Research and Development	15,828,006		41,128	41,128	15,869,134
Central Supply and Maintenance	44,961				44,961
Administration and Associated Activities	1,460				1,460
Space	15,868				15,868
Classified Programs	1,613,137		108,282	108,282	1,721,419
Total Research, Development, Test & Evaluation	20,270,499		164,410	164,410	20,434,909

Department of the Navy
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(Dollars in Thousands)

Appropriation: 1319N Research, Development, Test & Eval, Navy

Line No	Program Element Number	Item	Act	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted	Sec
1	0601103N	University Research Initiatives	01	137,515	161,433		161,433	U
2	0601152N	In-House Laboratory Independent Research	01	19,035	19,237		19,237	U
3	0601153N	Defense Research Sciences	01	448,084	499,102		499,102	U
	Basic	Research		604,634	679,772		679,772	
4	0602114N	Power Projection Applied Research	02	23,028	27,643		27,643	U
5	0602123N	Force Protection Applied Research	02	182,614	180,549		180,549	U
6	0602131M	Marine Corps Landing Force Technology	02	54,526	63,212		63,212	U
7	0602235N	Common Picture Applied Research	02	35,846	36,348		36,348	U
8	0602236N	Warfighter Sustainment Applied Research	02	48,606	65,782		65,782	U
9	0602271N	Electromagnetic Systems Applied Research	02	83,640	76,497		76,497	U
10	0602435N	Ocean Warfighting Environment Applied Research	02	72,530	89,998		89,998	U
11	0602651M	Joint Non-Lethal Weapons Applied Research	02	6,230	6,299		6,299	U
12	0602747N	Undersea Warfare Applied Research	02	59,644	78,049		78,049	U
13	0602750N	Future Naval Capabilities Applied Research	02	147,219	137,701		137,701	U
14	0602782N	Mine and Expeditionary Warfare Applied Research	02	35,430	38,214		38,214	U
15	0602792N	Innovative Naval Prototypes (INP) Applied Research	02	160,884	154,085		154,085	U

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Appropriation: 1319N Research, Development, Test & Eval, Navy

Line No	Program Element Number	Item	Act	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)	Sec
1	0601103N	University Research Initiatives	01	116,850				116,850	U
2	0601152N	In-House Laboratory Independent Research	01	19,121				19,121	U
3	0601153N	Defense Research Sciences	01	470,007				470,007	U
	Basic	Research		605,978				605,978	
4	0602114N	Power Projection Applied Research	02	18,546				18,546	U
5	0602123N	Force Protection Applied Research	02	119,517				119,517	U
6	0602131M	Marine Corps Landing Force Technology	02	56,604				56,604	U
7	0602235N	Common Picture Applied Research	02	49,297				49,297	U
8	0602236N	Warfighter Sustainment Applied Research	02	63,825				63,825	U
9	0602271N	Electromagnetic Systems Applied Research	02	83,497				83,497	U
10	0602435N	Ocean Warfighting Environment Applied Research	02	63,894				63,894	U
11	0602651M	Joint Non-Lethal Weapons Applied Research	02	6,346				6,346	U
12	0602747N	Undersea Warfare Applied Research	02	57,075				57,075	U
13	0602750N	Future Naval Capabilities Applied Research	02	154,755				154,755	U
14	0602782N	Mine and Expeditionary Warfare Applied Research	02	36,074				36,074	U
15	0602792N	Innovative Naval Prototypes (INP) Applied Research	02	153,062				153,062	U

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Appropriation: 1319N Research, Development, Test & Eval, Navy

Line No	Program Element Number	Item	Act	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted	Sec
16	0602861N	Science and Technology Management - ONR Field Acitivities	02	65,222	64,418		64,418	U
		Applied Research		975,419	1,018,795		1,018,795	
17	0603123N	Force Protection Advanced Technology	03	52,785	32,615		32,615	U
18	0603271N	Electromagnetic Systems Advanced Technology	03	9,231	8,804		8,804	U
19	0603640M	USMC Advanced Technology Demonstration (ATD)	03	164,992	174,809		174,809	U
20	0603651M	Joint Non-Lethal Weapons Technology Development	03	13,090	13,313		13,313	U
21	0603673N	Future Naval Capabilities Advanced Technology Development	03	215,946	214,184		214,184	U
22	0603680N	Manufacturing Technology Program	03	66,173	58,657		58,657	U
23	0603729N	Warfighter Protection Advanced Technology	03	42,895	41,377		41,377	U
24	0603747N	Undersea Warfare Advanced Technology	03	9,657				U
25	0603758N	Navy Warfighting Experiments and Demonstrations	03	63,867	65,885		65,885	U
26	0603782N	Mine and Expeditionary Warfare Advanced Technology	03	14,826	39,672		39,672	U
27	0603801N	Innovative Naval Prototypes (INP) Advanced Technology Development	03	246,609	202,394		202,394	U
		Advanced Technology Development		900,071	851,710		851,710	
28	0603207N	Air/Ocean Tactical Applications	04	47,422	29,747		29,747	U
29	0603216N	Aviation Survivability	04	5,450	7,050		7,050	U

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Line No	Program Element Number	Item	Act	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)	Sec
16	0602861N	Science and Technology Management - ONR Field Acitivities	02	73,961				73,961	U
		Applied Research		936,453				936,453	
17	0603123N	Force Protection Advanced Technology	03	35,286				35,286	U
18	0603271N	Electromagnetic Systems Advanced Technology	03	9,499				9,499	U
19	0603640M	USMC Advanced Technology Demonstration (ATD)	03	172,847				172,847	U
20	0603651M	Joint Non-Lethal Weapons Technology Development	03	13,307				13,307	U
21	0603673N	Future Naval Capabilities Advanced Technology Development	03	231,907				231,907	U
22	0603680N	Manufacturing Technology Program	03	60,138				60,138	U
23	0603729N	Warfighter Protection Advanced Technology	03	4,849				4,849	U
24	0603747N	Undersea Warfare Advanced Technology	03						U
25	0603758N	Navy Warfighting Experiments and Demonstrations	03	67,739				67,739	U
26	0603782N	Mine and Expeditionary Warfare Advanced Technology	03	13,335				13,335	U
27	0603801N	Innovative Naval Prototypes (INP) Advanced Technology Development	03	133,303				133,303	U
		Advanced Technology Development		742,210				742,210	
28	0603207N	Air/Ocean Tactical Applications	04	32,643		2,400	2,400	35,043	U
29	0603216N	Aviation Survivability	04	11,919				11,919	U

Department of the Navy
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(Dollars in Thousands)

Appropriation: 1319N Research, Development, Test & Eval, Navy

Line No	Program Element Number	Item	Act	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted	Sec
30	0603251N	Aircraft Systems	04	693	793		793	U
31	0603254N	ASW Systems Development	04	7,466	7,044		7,044	U
32	0603261N	Tactical Airborne Reconnaissance	04	3,692	3,540		3,540	U
33	0603382N	Advanced Combat Systems Technology	04	4,450	39,240		39,240	U
34	0603502N	Surface and Shallow Water Mine Countermeasures	04	69,906	120,348		120,348	U
35	0603506N	Surface Ship Torpedo Defense	04	24,174	7,100		7,100	U
36	0603512N	Carrier Systems Development	04	9,184	5,440		5,440	U
37	0603525N	PILOT FISH	04	111,278	136,533		136,533	U
38	0603527N	RETRACT LARCH	04	32,608	11,745	18,000	29,745	U
39	0603536N	RETRACT JUNIPER	04	126,210	113,679		113,679	U
40	0603542N	Radiological Control	04	716	740		740	U
41	0603553N	Surface ASW	04	1,092	1,122		1,122	U
42	0603561N	Advanced Submarine System Development	04	91,927	105,809		105,809	U
43	0603562N	Submarine Tactical Warfare Systems	04	13,597	12,374		12,374	U
44	0603563N	Ship Concept Advanced Design	04	23,856	74,603		74,603	U
45	0603564N	Ship Preliminary Design & Feasibility Studies	04	18,369	13,348		13,348	U
46	0603570N	Advanced Nuclear Power Systems	04	329,500	256,137		256,137	U
47	0603573N	Advanced Surface Machinery Systems	04	22,406	27,109		27,109	U
48	0603576N	CHALK EAGLE	04	188,927	29,353		29,353	U

Department of the Navy
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Appropriation: 1319N Research, Development, Test & Eval, Navy

Line No	Program Element Number	Item	Act	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)	Sec
30	0603251N	Aircraft Systems	04	1,473				1,473	U
31	0603254N	ASW Systems Development	04	7,172				7,172	U
32	0603261N	Tactical Airborne Reconnaissance	04	3,419				3,419	U
33	0603382N	Advanced Combat Systems Technology	04	64,694				64,694	U
34	0603502N	Surface and Shallow Water Mine Countermeasures	04	507,000				507,000	U
35	0603506N	Surface Ship Torpedo Defense	04	15,800				15,800	U
36	0603512N	Carrier Systems Development	04	4,997				4,997	U
37	0603525N	PILOT FISH	04	291,148				291,148	U
38	0603527N	RETRACT LARCH	04	11,980		22,000	22,000	33,980	U
39	0603536N	RETRACT JUNIPER	04	129,163				129,163	U
40	0603542N	Radiological Control	04	689				689	U
41	0603553N	Surface ASW	04	1,137				1,137	U
42	0603561N	Advanced Submarine System Development	04	148,756				148,756	U
43	0603562N	Submarine Tactical Warfare Systems	04	11,192				11,192	U
44	0603563N	Ship Concept Advanced Design	04	81,846				81,846	U
45	0603564N	Ship Preliminary Design & Feasibility Studies	04	69,084				69,084	U
46	0603570N	Advanced Nuclear Power Systems	04	181,652				181,652	U
47	0603573N	Advanced Surface Machinery Systems	04	25,408				25,408	U
48	0603576N	CHALK EAGLE	04	64,877				64,877	U

Department of the Navy
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Appropriation: 1319N Research, Development, Test & Eval, Navy

Line No	Program Element Number	Item	Act	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted	Sec
49	0603581N	Littoral Combat Ship (LCS)	04	49,308	37,997		37,997	U
50	0603582N	Combat System Integration	04	15,471	16,351		16,351	U
51	0603595N	Ohio Replacement	04	775,624	542,846		542,846	U
52	0603596N	LCS Mission Modules	04	100,470	103,559		103,559	U
53	0603597N	Automated Test and Analysis	04	24,145	37,931		37,931	U
54	0603599N	Frigate Development	04	137,655	132,775		132,775	U
55	0603609N	Conventional Munitions	04	13,699	9,307		9,307	U
56	0603635M	Marine Corps Ground Combat/Support System	04	771				U
57	0603654N	Joint Service Explosive Ordnance Development	04	77,409	47,857	13,900	61,757	U
58	0603713N	Ocean Engineering Technology Development	04	8,853	5,915		5,915	U
59	0603721N	Environmental Protection	04	23,237	19,811		19,811	U
60	0603724N	Navy Energy Program	04	42,425	32,656		32,656	U
61	0603725N	Facilities Improvement	04	2,794	5,301		5,301	U
62	0603734N	CHALK CORAL	04	237,402	267,477		267,477	U
63	0603739N	Navy Logistic Productivity	04	2,882	2,913		2,913	U
64	0603746N	RETRACT MAPLE	04	287,865	318,878		318,878	U
65	0603748N	LINK PLUMERIA	04	375,595	381,268		381,268	U
66	0603751N	RETRACT ELM	04	52,080	58,192		58,192	U
67	0603764N	LINK EVERGREEN	04	47,115				U

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Appropriation: 1319N Research, Development, Test & Eval, Navy

Line No	Program Element Number	Item	Act	FY 2020 Base	FY 2020 OCO for Base Requirements	FY 2020 OCO for Direct War and Enduring Costs	FY 2020 Total OCO	FY 2020 Total (Base + OCO)	Sec
49	0603581N	Littoral Combat Ship (LCS)	04	9,934				9,934	U
50	0603582N	Combat System Integration	04	17,251				17,251	U
51	0603595N	Ohio Replacement	04	419,051				419,051	U
52	0603596N	LCS Mission Modules	04	108,505				108,505	U
53	0603597N	Automated Test and Analysis	04	7,653				7,653	U
54	0603599N	Frigate Development	04	59,007				59,007	U
55	0603609N	Conventional Munitions	04	9,988				9,988	U
56	0603635M	Marine Corps Ground Combat/Support System	04	86,464				86,464	U
57	0603654N	Joint Service Explosive Ordnance Development	04	33,478		14,178	14,178	47,656	U
58	0603713N	Ocean Engineering Technology Development	04	5,619				5,619	U
59	0603721N	Environmental Protection	04	20,564				20,564	U
60	0603724N	Navy Energy Program	04	26,514				26,514	U
61	0603725N	Facilities Improvement	04	3,440				3,440	U
62	0603734N	CHALK CORAL	04	346,800				346,800	U
63	0603739N	Navy Logistic Productivity	04	3,857				3,857	U
64	0603746N	RETRACT MAPLE	04	258,519				258,519	U
65	0603748N	LINK PLUMERIA	04	403,909				403,909	U
66	0603751N	RETRACT ELM	04	63,434				63,434	U
67	0603764N	LINK EVERGREEN	04	184,110				184,110	U

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Appropriation: 1319N Research, Development, Test & Eval, Navy

Line No	Program Element Number	Item	Act	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted	Sec
68	0603790N	NATO Research and Development	04	8,752	9,652		9,652	U
69	0603795N	Land Attack Technology	04	16,684	5,700	1,400	7,100	U
70	0603851M	Joint Non-Lethal Weapons Testing	04	23,934	27,581		27,581	U
71	0603860N	Joint Precision Approach and Landing Systems - Dem/Val	04	103,984	101,566		101,566	U
72	0603925N	Directed Energy and Electric Weapon Systems	04	92,856	142,814		142,814	U
73	0604014N	F/A -18 Infrared Search and Track (IRST)	04		108,689		108,689	U
74	0604027N	Digital Warfare Office	04	14,476	20,000		20,000	U
75	0604028N	Small and Medium Unmanned Undersea Vehicles	04		16,717		16,717	U
76	0604029N	Unmanned Undersea Vehicle Core Technologies	04		27,483		27,483	U
77	0604030N	Rapid Prototyping, Experimentation and Demonstration.	04	25,225	28,596		28,596	U
78	0604031N	Large Unmanned Undersea Vehicles	04	23,886	60,304		60,304	U
79	0604112N	Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78 - 80)	04	82,549	83,121		83,121	U
80	0604126N	Littoral Airborne MCM	04	11,314	14,625		14,625	U
81	0604127N	Surface Mine Countermeasures	04	12,525	15,527		15,527	U
82	0604272N	Tactical Air Directional Infrared Countermeasures (TADIRCM)	04	51,311	47,278		47,278	U
83	0604286M	Marine Corps Additive Manufacturing Technology Development	04	6,168				U

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68	0603790N	NATO Research and Development	04	7,697				7,697	U
69	0603795N	Land Attack Technology	04	9,086		1,428	1,428	10,514	U
70	0603851M	Joint Non-Lethal Weapons Testing	04	28,466				28,466	U
71	0603860N	Joint Precision Approach and Landing Systems - Dem/Val	04	51,341				51,341	U
72	0603925N	Directed Energy and Electric Weapon Systems	04	118,169				118,169	U
73	0604014N	F/A -18 Infrared Search and Track (IRST)	04	113,456				113,456	U
74	0604027N	Digital Warfare Office	04	50,120				50,120	U
75	0604028N	Small and Medium Unmanned Undersea Vehicles	04	32,527				32,527	U
76	0604029N	Unmanned Undersea Vehicle Core Technologies	04	54,376				54,376	U
77	0604030N	Rapid Prototyping, Experimentation and Demonstration.	04	36,197				36,197	U
78	0604031N	Large Unmanned Undersea Vehicles	04	68,310				68,310	U
79	0604112N	Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78 - 80)	04	121,310				121,310	U
80	0604126N	Littoral Airborne MCM	04	17,248				17,248	U
81	0604127N	Surface Mine Countermeasures	04	18,735				18,735	U
82	0604272N	Tactical Air Directional Infrared Countermeasures (TADIRCM)	04	68,346				68,346	U
83	0604286M	Marine Corps Additive Manufacturing Technology Development	04						U

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84	0604289M	Next Generation Logistics	04		6,073		6,073	U
85	0604320M	Rapid Technology Capability Prototype	04	16,443	7,107		7,107	U
86	0604454N	LX (R)	04	9,431	5,549		5,549	U
87	0604536N	Advanced Undersea Prototyping	04	64,038	112,669		112,669	U
88	0604636N	Counter Unmanned Aircraft Systems (C-UAS)	04					U
89	0604659N	Precision Strike Weapons Development Program	04	20,279	91,833		91,833	U
90	0604707N	Space and Electronic Warfare (SEW) Architecture/Engineering Support	04	41,214	7,230		7,230	U
91	0604786N	Offensive Anti-Surface Warfare Weapon Development	04	163,843	139,261		139,261	U
92	0303354N	ASW Systems Development - MIP	04	8,278	8,889		8,889	U
93	0304240M	Advanced Tactical Unmanned Aircraft System	04	5,200	17,561		17,561	U
94	0304240N	Advanced Tactical Unmanned Aircraft System	04		9,300		9,300	U
95	0304270N	Electronic Warfare Development - MIP	04	527	466		466	U
		Advanced Component Development & Prototypes		4,210,640	4,139,479	33,300	4,172,779	
96	0603208N	Training System Aircraft	05	16,343	12,798		12,798	U
97	0604212N	Other Helo Development	05	26,423	23,579		23,579	U
98	0604214M	AV-8B Aircraft - Eng Dev	05		46,363		46,363	U
99	0604214N	AV-8B Aircraft - Eng Dev	05	41,261				U

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84	0604289M	Next Generation Logistics	04	4,420				4,420	U
85	0604320M	Rapid Technology Capability Prototype	04	4,558				4,558	U
86	0604454N	LX (R)	04	12,500				12,500	U
87	0604536N	Advanced Undersea Prototyping	04	181,967				181,967	U
88	0604636N	Counter Unmanned Aircraft Systems (C-UAS)	04	5,500				5,500	U
89	0604659N	Precision Strike Weapons Development Program	04	718,148				718,148	U
90	0604707N	Space and Electronic Warfare (SEW) Architecture/Engineering Support	04	5,263				5,263	U
91	0604786N	Offensive Anti-Surface Warfare Weapon Development	04	65,419				65,419	U
92	0303354N	ASW Systems Development - MIP	04	9,991				9,991	U
93	0304240M	Advanced Tactical Unmanned Aircraft System	04	21,157				21,157	U
94	0304240N	Advanced Tactical Unmanned Aircraft System	04						U
95	0304270N	Electronic Warfare Development - MIP	04	609				609	U
		Advanced Component Development & Prototypes		5,559,062		40,006	40,006	5,599,068	
96	0603208N	Training System Aircraft	05	15,514				15,514	U
97	0604212N	Other Helo Development	05	28,835				28,835	U
98	0604214M	AV-8B Aircraft - Eng Dev	05	27,441				27,441	U
99	0604214N	AV-8B Aircraft - Eng Dev	05						U

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100	0604215N	Standards Development	05	2,711	3,771		3,771	U
101	0604216N	Multi-Mission Helicopter Upgrade Development	05	5,313	16,611		16,611	U
102	0604218N	Air/Ocean Equipment Engineering	05	5,583	15,582		15,582	U
103	0604221N	P-3 Modernization Program	05	1,331	2,134		2,134	U
104	0604230N	Warfare Support System	05	19,004	9,729		9,729	U
105	0604231N	Tactical Command System	05	37,609	54,300		54,300	U
106	0604234N	Advanced Hawkeye	05	283,497	210,565		210,565	U
107	0604245M	H-1 Upgrades	05		54,320		54,320	U
108	0604245N	H-1 Upgrades	05	59,806				U
109	0604261N	Acoustic Search Sensors	05	36,310	42,485		42,485	U
110	0604262N	V-22A	05	176,804	135,504		135,504	U
111	0604264N	Air Crew Systems Development	05	7,174	30,980		30,980	U
112	0604269N	EA-18	05	137,029	242,719		242,719	U
113	0604270N	Electronic Warfare Development	05	50,613	83,624		83,624	U
114	0604273M	Executive Helo Development	05		245,064		245,064	U
115	0604273N	Executive Helo Development	05	430,647				U
116	0604274N	Next Generation Jammer (NGJ)	05	584,538	449,429		449,429	U
117	0604280N	Joint Tactical Radio System - Navy (JTRS-Navy)	05	5,172	3,272		3,272	U
118	0604282N	Next Generation Jammer (NGJ) Increment II	05	55,194	93,482		93,482	U

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100	0604215N	Standards Development	05	3,642				3,642	U
101	0604216N	Multi-Mission Helicopter Upgrade Development	05	19,196				19,196	U
102	0604218N	Air/Ocean Equipment Engineering	05						U
103	0604221N	P-3 Modernization Program	05						U
104	0604230N	Warfare Support System	05	8,601				8,601	U
105	0604231N	Tactical Command System	05	77,232				77,232	U
106	0604234N	Advanced Hawkeye	05	232,752				232,752	U
107	0604245M	H-1 Upgrades	05	65,359				65,359	U
108	0604245N	H-1 Upgrades	05						U
109	0604261N	Acoustic Search Sensors	05	47,013				47,013	U
110	0604262N	V-22A	05	185,105				185,105	U
111	0604264N	Air Crew Systems Development	05	21,172				21,172	U
112	0604269N	EA-18	05	143,585				143,585	U
113	0604270N	Electronic Warfare Development	05	116,811				116,811	U
114	0604273M	Executive Helo Development	05	187,436				187,436	U
115	0604273N	Executive Helo Development	05						U
116	0604274N	Next Generation Jammer (NGJ)	05	524,261				524,261	U
117	0604280N	Joint Tactical Radio System - Navy (JTRS-Navy)	05	192,345				192,345	U
118	0604282N	Next Generation Jammer (NGJ) Increment II	05	111,068				111,068	U

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119	0604307N	Surface Combatant Combat System Engineering	05	340,760	379,116		379,116	U
120	0604311N	LPD-17 Class Systems Integration	05	665	939		939	U
121	0604329N	Small Diameter Bomb (SDB)	05	99,286	96,980		96,980	U
122	0604366N	Standard Missile Improvements	05	114,802	190,881		190,881	U
123	0604373N	Airborne MCM	05	15,203	8,351		8,351	U
124	0604378N	Naval Integrated Fire Control - Counter Air Systems Engineering	05	24,801	33,429		33,429	U
125	0604501N	Advanced Above Water Sensors	05	84,507	33,884		33,884	U
126	0604503N	SSN-688 and Trident Modernization	05	142,167	126,932		126,932	U
127	0604504N	Air Control	05	68,012	61,498		61,498	U
128	0604512N	Shipboard Aviation Systems	05	174,034	13,710		13,710	U
129	0604518N	Combat Information Center Conversion	05	4,294	19,263		19,263	U
130	0604522N	Air and Missile Defense Radar (AMDR) System	05	49,643	27,008		27,008	U
131	0604530N	Advanced Arresting Gear (AAG)	05		172,173		172,173	U
132	0604558N	New Design SSN	05	117,887	180,233		180,233	U
133	0604562N	Submarine Tactical Warfare System	05	44,703	80,324		80,324	U
134	0604567N	Ship Contract Design/ Live Fire T&E	05	65,857	71,062		71,062	U
135	0604574N	Navy Tactical Computer Resources	05	4,745	4,642		4,642	U
136	0604580N	Virginia Payload Module (VPM)	05	70,579				U
137	0604601N	Mine Development	05	24,640	21,747		21,747	U

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119	0604307N	Surface Combatant Combat System Engineering	05	415,625				415,625	U
120	0604311N	LPD-17 Class Systems Integration	05	640				640	U
121	0604329N	Small Diameter Bomb (SDB)	05	50,096				50,096	U
122	0604366N	Standard Missile Improvements	05	232,391				232,391	U
123	0604373N	Airborne MCM	05	10,916				10,916	U
124	0604378N	Naval Integrated Fire Control - Counter Air Systems Engineering	05	33,379				33,379	U
125	0604501N	Advanced Above Water Sensors	05	34,554				34,554	U
126	0604503N	SSN-688 and Trident Modernization	05	84,663				84,663	U
127	0604504N	Air Control	05	44,923				44,923	U
128	0604512N	Shipboard Aviation Systems	05	10,632				10,632	U
129	0604518N	Combat Information Center Conversion	05	16,094				16,094	U
130	0604522N	Air and Missile Defense Radar (AMDR) System	05	55,349				55,349	U
131	0604530N	Advanced Arresting Gear (AAG)	05	123,490				123,490	U
132	0604558N	New Design SSN	05	121,010				121,010	U
133	0604562N	Submarine Tactical Warfare System	05	62,426				62,426	U
134	0604567N	Ship Contract Design/ Live Fire T&E	05	46,809				46,809	U
135	0604574N	Navy Tactical Computer Resources	05	3,692				3,692	U
136	0604580N	Virginia Payload Module (VPM)	05						U
137	0604601N	Mine Development	05	28,964				28,964	U

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138	0604610N	Lightweight Torpedo Development	05	21,057	63,147		63,147	U
139	0604654N	Joint Service Explosive Ordnance Development	05	7,449	7,107		7,107	U
140	0604657M	USMC Ground Combat/Supporting Arms Systems - Eng Dev	05					U
141	0604703N	Personnel, Training, Simulation, and Human Factors	05	24,229	6,539		6,539	U
142	0604727N	Joint Standoff Weapon Systems	05	418	441		441	U
143	0604755N	Ship Self Defense (Detect & Control)	05	160,475	180,391	1,100	181,491	U
144	0604756N	Ship Self Defense (Engage: Hard Kill)	05	214,132	193,244		193,244	U
145	0604757N	Ship Self Defense (Engage: Soft Kill/EW)	05	126,037	120,210		120,210	U
146	0604761N	Intelligence Engineering	05	44,855	25,965		25,965	U
147	0604771N	Medical Development	05	36,392	38,095		38,095	U
148	0604777N	Navigation/ID System	05	74,984	126,026		126,026	U
149	0604800M	Joint Strike Fighter (JSF) - EMD	05	157,162	66,566		66,566	U
150	0604800N	Joint Strike Fighter (JSF) - EMD	05	105,648	65,494		65,494	U
151	0604810M	Joint Strike Fighter Follow On Modernization (FoM) - Marine Corps	05	139,369				U
152	0604810N	Joint Strike Fighter Follow On Modernization (FoM) - Navy	05	138,308				U
153	0605013M	Information Technology Development	05	14,497	11,030		11,030	U
154	0605013N	Information Technology Development	05	120,387	242,110		242,110	U

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138	0604610N	Lightweight Torpedo Development	05	148,349				148,349	U
139	0604654N	Joint Service Explosive Ordnance Development	05	8,237				8,237	U
140	0604657M	USMC Ground Combat/Supporting Arms Systems - Eng Dev	05	22,000				22,000	U
141	0604703N	Personnel, Training, Simulation, and Human Factors	05	5,500				5,500	U
142	0604727N	Joint Standoff Weapon Systems	05	18,725				18,725	U
143	0604755N	Ship Self Defense (Detect & Control)	05	192,603		1,122	1,122	193,725	U
144	0604756N	Ship Self Defense (Engage: Hard Kill)	05	137,268				137,268	U
145	0604757N	Ship Self Defense (Engage: Soft Kill/EW)	05	97,363				97,363	U
146	0604761N	Intelligence Engineering	05	26,710				26,710	U
147	0604771N	Medical Development	05	8,181				8,181	U
148	0604777N	Navigation/ID System	05	40,755				40,755	U
149	0604800M	Joint Strike Fighter (JSF) - EMD	05	1,710				1,710	U
150	0604800N	Joint Strike Fighter (JSF) - EMD	05	1,490				1,490	U
151	0604810M	Joint Strike Fighter Follow On Modernization (FoM) - Marine Corps	05						U
152	0604810N	Joint Strike Fighter Follow On Modernization (FoM) - Navy	05						U
153	0605013M	Information Technology Development	05	1,494				1,494	U
154	0605013N	Information Technology Development	05	384,162				384,162	U

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155	0605024N	Anti-Tamper Technology Support	05	3,900	5,618		5,618	U
156	0605212M	CH-53K RDTE	05		336,945		336,945	U
157	0605212N	CH-53K RDTE	05	329,367				U
158	0605215N	Mission Planning	05	36,108	32,714		32,714	U
159	0605217N	Common Avionics	05	47,338	51,486		51,486	U
160	0605220N	Ship to Shore Connector (SSC)	05	31,583	1,444		1,444	U
161	0605327N	T-AO 205 Class	05	1,895	1,298		1,298	U
162	0605414N	Unmanned Carrier Aviation (UCA)	05	194,176	518,942		518,942	U
163	0605450M	Joint Air-to-Ground Missile (JAGM)	05		16,559		16,559	U
164	0605450N	Joint Air-to-Ground Missile (JAGM)	05	14,457				U
165	0605500N	Multi-mission Maritime Aircraft (MMA)	05	11,422	34,196		34,196	U
166	0605504N	Multi-Mission Maritime (MMA) Increment III	05	123,752	163,809		163,809	U
167	0605611M	Marine Corps Assault Vehicles System Development & Demonstration	05	150,381	66,137		66,137	U
168	0605813M	Joint Light Tactical Vehicle (JLTV) System Development & Demonstration	05	19,467				U
169	0204202N	DDG-1000	05	134,664	140,264		140,264	U
170	0303267N	Auctioned Spectrum Relocation Fund***	05	97,558				U
171	0303467N	SENSR Spectrum Pipeline SRF***	05	1,773				U
172	0304785N	Tactical Cryptologic Systems	05	22,762	42,398		42,398	U

***Funding in this Program Element was transferred during the year of execution from the Spectrum Relocation Fund (SRF) in support of the Advanced Wireless Services 3 (AWS-3) auction and is associated with the reallocation or sharing of the 1755-1780 MHz and 1695-1710 MHz bands. The SRF is administered by the Office of Management and Budget (OMB), which approves SRF transfers to federal agencies on an annual basis in consultation with the National Telecommunications and Information Administration (NTIA).

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155	0605024N	Anti-Tamper Technology Support	05	4,882				4,882	U
156	0605212M	CH-53K RDTE	05	516,955				516,955	U
157	0605212N	CH-53K RDTE	05						U
158	0605215N	Mission Planning	05	75,886				75,886	U
159	0605217N	Common Avionics	05	43,187				43,187	U
160	0605220N	Ship to Shore Connector (SSC)	05	4,909				4,909	U
161	0605327N	T-AO 205 Class	05	1,682				1,682	U
162	0605414N	Unmanned Carrier Aviation (UCA)	05	671,258				671,258	U
163	0605450M	Joint Air-to-Ground Missile (JAGM)	05	18,393				18,393	U
164	0605450N	Joint Air-to-Ground Missile (JAGM)	05						U
165	0605500N	Multi-mission Maritime Aircraft (MMA)	05	21,472				21,472	U
166	0605504N	Multi-Mission Maritime (MMA) Increment III	05	177,234				177,234	U
167	0605611M	Marine Corps Assault Vehicles System Development & Demonstration	05	77,322				77,322	U
168	0605813M	Joint Light Tactical Vehicle (JLTV) System Development & Demonstration	05	2,105				2,105	U
169	0204202N	DDG-1000	05	111,435				111,435	U
170	0303267N	Auctioned Spectrum Relocation Fund***	05						U
171	0303467N	SENSR Spectrum Pipeline SRF***	05						U
172	0304785N	Tactical Cryptologic Systems	05	101,339				101,339	U

***Funding in this Program Element was transferred during the year of execution from the Spectrum Relocation Fund (SRF) in support of the Advanced Wireless Services 3 (AWS-3) auction and is associated with the reallocation or sharing of the 1755-1780 MHz and 1695-1710 MHz bands. The SRF is administered by the Office of Management and Budget (OMB), which approves SRF transfers to federal agencies on an annual basis in consultation with the National Telecommunications and Information Administration (NTIA).

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173	0306250M	Cyber Operations Technology Development	05	2,960	6,808		6,808	U
		System Development & Demonstration		6,037,909	5,863,466	1,100	5,864,566	
174	0604256N	Threat Simulator Development	06	89,491	94,576		94,576	U
175	0604258N	Target Systems Development	06	18,737	10,981		10,981	U
176	0604759N	Major T&E Investment	06	68,977	90,514		90,514	U
177	0605126N	Joint Theater Air and Missile Defense Organization	06	140	48		48	U
178	0605152N	Studies and Analysis Support - Navy	06	4,438	3,942		3,942	U
179	0605154N	Center for Naval Analyses	06	44,302	42,693		42,693	U
180	0605285N	Next Generation Fighter	06		5,000		5,000	U
181	0605502N	Small Business Innovative Research	06	407,133				U
182	0605804N	Technical Information Services	06	1,280	1,029		1,029	U
183	0605853N	Management, Technical & International Support	06	135,102	86,932		86,932	U
184	0605856N	Strategic Technical Support	06	3,909	4,231		4,231	U
185	0605861N	RDT&E Science and Technology Management	06	1,104	1,072		1,072	U
186	0605863N	RDT&E Ship and Aircraft Support	06	105,019	97,471		97,471	U
187	0605864N	Test and Evaluation Support	06	369,056	373,834		373,834	U
188	0605865N	Operational Test and Evaluation Capability	06	20,298	21,554		21,554	U

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173	0306250M	Cyber Operations Technology Development	05	26,406				26,406	U
		System Development & Demonstration		6,332,033		1,122	1,122	6,333,155	
174	0604256N	Threat Simulator Development	06	66,678				66,678	U
175	0604258N	Target Systems Development	06	12,027				12,027	U
176	0604759N	Major T&E Investment	06	85,348				85,348	U
177	0605126N	Joint Theater Air and Missile Defense Organization	06						U
178	0605152N	Studies and Analysis Support - Navy	06	3,908				3,908	U
179	0605154N	Center for Naval Analyses	06	47,669				47,669	U
180	0605285N	Next Generation Fighter	06	20,698				20,698	U
181	0605502N	Small Business Innovative Research	06						U
182	0605804N	Technical Information Services	06	988				988	U
183	0605853N	Management, Technical & International Support	06	102,401				102,401	U
184	0605856N	Strategic Technical Support	06	3,742				3,742	U
185	0605861N	RDT&E Science and Technology Management	06						U
186	0605863N	RDT&E Ship and Aircraft Support	06	93,872				93,872	U
187	0605864N	Test and Evaluation Support	06	394,020				394,020	U
188	0605865N	Operational Test and Evaluation Capability	06	25,145				25,145	U

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Line No	Program Element Number	Item	Act	FY 2018 (Base + OCO)	FY 2019 Base Enacted	FY 2019 OCO Enacted	FY 2019 Total Enacted	Sec
189	0605866N	Navy Space and Electronic Warfare (SEW) Support	06	16,274	16,227		16,227	U
190	0605867N	SEW Surveillance/Reconnaissance Support	06					U
191	0605873M	Marine Corps Program Wide Support	06	21,423	21,538		21,538	U
192	0605898N	Management HQ - R&D	06	43,266	41,765		41,765	U
193	0606355N	Warfare Innovation Management	06	27,759	41,918		41,918	U
194	0606942M	Assessments and Evaluations Cyber Vulnerabilities	06		7,000		7,000	U
195	0606942N	Assessments and Evaluations Cyber Vulnerabilities	06		48,800		48,800	U
196	0305327N	Insider Threat	06		1,682		1,682	U
197	0902498N	Management Headquarters (Departmental Support Activities)	06	1,749	1,579		1,579	U
198	0909999N	Financing for Cancelled Account Adjustments	06	71				U
199	1206867N	SEW Surveillance/Reconnaissance Support	06	9,408	8,684		8,684	U
		Management Support		1,388,936	1,023,070		1,023,070	
201	0604014N	F/A -18 Infrared Search and Track (IRST)	07	68,087				U
202	0604227N	HARPOON Modifications	07		5,197		5,197	U
203	0604840M	F-35 C2D2	07		234,107		234,107	U
204	0604840N	F-35 C2D2	07		227,998		227,998	U

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189	0605866N	Navy Space and Electronic Warfare (SEW) Support	06	15,773				15,773	U
190	0605867N	SEW Surveillance/Reconnaissance Support	06	8,402				8,402	U
191	0605873M	Marine Corps Program Wide Support	06	37,265				37,265	U
192	0605898N	Management HQ - R&D	06	39,673				39,673	U
193	0606355N	Warfare Innovation Management	06	28,750				28,750	U
194	0606942M	Assessments and Evaluations Cyber Vulnerabilities	06						U
195	0606942N	Assessments and Evaluations Cyber Vulnerabilities	06						U
196	0305327N	Insider Threat	06	2,645				2,645	U
197	0902498N	Management Headquarters (Departmental Support Activities)	06	1,460				1,460	U
198	0909999N	Financing for Cancelled Account Adjustments	06						U
199	1206867N	SEW Surveillance/Reconnaissance Support	06						U
		Management Support		990,464				990,464	
201	0604014N	F/A -18 Infrared Search and Track (IRST)	07						U
202	0604227N	HARPOON Modifications	07	2,302				2,302	U
203	0604840M	F-35 C2D2	07	422,881				422,881	U
204	0604840N	F-35 C2D2	07	383,741				383,741	U

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205	0607658N	Cooperative Engagement Capability (CEC)	07	88,088	128,815		128,815	U
206	0607700N	Deployable Joint Command and Control	07	3,093	3,127		3,127	U
207	0101221N	Strategic Sub & Weapons System Support	07	130,652	148,379		148,379	U
208	0101224N	SSBN Security Technology Program	07	35,105	41,959		41,959	U
209	0101226N	Submarine Acoustic Warfare Development	07	9,439	11,311		11,311	U
210	0101402N	Navy Strategic Communications	07	17,624	38,661		38,661	U
211	0204136N	F/A-18 Squadrons	07	133,544	204,886		204,886	U
212	0204163N	Fleet Telecommunications (Tactical)	07	8,465	1,344		1,344	U
213	0204228N	Surface Support	07	20,587	9,708		9,708	U
214	0204229N	Tomahawk and Tomahawk Mission Planning Center (TMPC)	07	100,011	252,395		252,395	U
215	0204311N	Integrated Surveillance System	07	55,164	71,959		71,959	U
216	0204313N	Ship-Towed Array Surveillance Systems	07		15,454		15,454	U
217	0204413N	Amphibious Tactical Support Units (Displacement Craft)	07	2,346	6,073		6,073	U
218	0204460M	Ground/Air Task Oriented Radar (G/ ATOR)	07	53,605	44,579		44,579	U
219	0204571N	Consolidated Training Systems Development	07	64,585	104,903		104,903	U
220	0204574N	Cryptologic Direct Support	07	2,355	4,544		4,544	U

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205	0607658N	Cooperative Engagement Capability (CEC)	07	127,924				127,924	U
206	0607700N	Deployable Joint Command and Control	07						U
207	0101221N	Strategic Sub & Weapons System Support	07	157,676				157,676	U
208	0101224N	SSBN Security Technology Program	07	43,354				43,354	U
209	0101226N	Submarine Acoustic Warfare Development	07	6,815				6,815	U
210	0101402N	Navy Strategic Communications	07	31,174				31,174	U
211	0204136N	F/A-18 Squadrons	07	213,715				213,715	U
212	0204163N	Fleet Telecommunications (Tactical)	07						U
213	0204228N	Surface Support	07	36,389				36,389	U
214	0204229N	Tomahawk and Tomahawk Mission Planning Center (TMPC)	07	320,134				320,134	U
215	0204311N	Integrated Surveillance System	07	88,382				88,382	U
216	0204313N	Ship-Towed Array Surveillance Systems	07	14,449				14,449	U
217	0204413N	Amphibious Tactical Support Units (Displacement Craft)	07	6,931				6,931	U
218	0204460M	Ground/Air Task Oriented Radar (G/ATOR)	07	23,891				23,891	U
219	0204571N	Consolidated Training Systems Development	07	129,873				129,873	U
220	0204574N	Cryptologic Direct Support	07						U

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221	0204575N	Electronic Warfare (EW) Readiness Support	07	49,094	66,889		66,889	U
222	0205601N	HARM Improvement	07	70,415	120,762		120,762	U
223	0205604N	Tactical Data Links	07	75,523	88,979		88,979	U
224	0205620N	Surface ASW Combat System Integration	07	28,410	26,321		26,321	U
225	0205632N	MK-48 ADCAP	07	48,740	68,255		68,255	U
226	0205633N	Aviation Improvements	07	120,940	134,823		134,823	U
227	0205675N	Operational Nuclear Power Systems	07	127,445	117,028		117,028	U
228	0206313M	Marine Corps Communications Systems	07	170,529	172,683	16,130	188,813	U
229	0206335M	Common Aviation Command and Control System (CAC2S)	07	6,976	4,760		4,760	U
230	0206623M	Marine Corps Ground Combat/ Supporting Arms Systems	07	68,941	100,850		100,850	U
231	0206624M	Marine Corps Combat Services Support	07	24,915	29,905		29,905	U
232	0206625M	USMC Intelligence/Electronic Warfare Systems (MIP)	07	30,630	37,821		37,821	U
233	0206629M	Amphibious Assault Vehicle	07	53,404	20,690		20,690	U
234	0207161N	Tactical AIM Missiles	07	34,063	40,121		40,121	U
235	0207163N	Advanced Medium Range Air-to-Air Missile (AMRAAM)	07	29,486	28,235		28,235	U
239	0303109N	Satellite Communications (SPACE)	07					U
240	0303138N	Consolidated Afloat Network Enterprise Services (CANES)	07	24,197	23,697		23,697	U

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221	0204575N	Electronic Warfare (EW) Readiness Support	07	82,325				82,325	U
222	0205601N	HARM Improvement	07	138,431				138,431	U
223	0205604N	Tactical Data Links	07						U
224	0205620N	Surface ASW Combat System Integration	07	29,572				29,572	U
225	0205632N	MK-48 ADCAP	07	85,973				85,973	U
226	0205633N	Aviation Improvements	07	125,461				125,461	U
227	0205675N	Operational Nuclear Power Systems	07	106,192				106,192	U
228	0206313M	Marine Corps Communications Systems	07	143,317		15,000	15,000	158,317	U
229	0206335M	Common Aviation Command and Control System (CAC2S)	07	4,489				4,489	U
230	0206623M	Marine Corps Ground Combat/ Supporting Arms Systems	07	51,788				51,788	U
231	0206624M	Marine Corps Combat Services Support	07	37,761				37,761	U
232	0206625M	USMC Intelligence/Electronic Warfare Systems (MIP)	07	21,458				21,458	U
233	0206629M	Amphibious Assault Vehicle	07	5,476				5,476	U
234	0207161N	Tactical AIM Missiles	07	19,488				19,488	U
235	0207163N	Advanced Medium Range Air-to-Air Missile (AMRAAM)	07	39,029				39,029	U
239	0303109N	Satellite Communications (SPACE)	07	34,344				34,344	U
240	0303138N	Consolidated Afloat Network Enterprise Services (CANES)	07	22,873				22,873	U

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241	0303140N	Information Systems Security Program	07	49,310	44,228		44,228	U
243	0305192N	Military Intelligence Program (MIP) Activities	07	6,934	6,081		6,081	U
244	0305204N	Tactical Unmanned Aerial Vehicles	07	7,770	8,529		8,529	U
245	0305205N	UAS Integration and Interoperability	07	20,848	24,663		24,663	U
246	0305208M	Distributed Common Ground/Surface Systems	07	13,338	7,610		7,610	U
247	0305208N	Distributed Common Ground/Surface Systems	07	40,150	42,846		42,846	U
248	0305220N	MQ-4C Triton	07	94,115	14,395		14,395	U
249	0305231N	MQ-8 UAV	07	62,656	24,143		24,143	U
250	0305232M	RQ-11 UAV	07	2,002	524		524	U
251	0305234N	Small (Level 0) Tactical UAS (STUASL0)	07	4,827	5,265		5,265	U
252	0305239M	RQ-21A	07	10,500	6,000		6,000	U
253	0305241N	Multi-Intelligence Sensor Development	07	93,020	81,231		81,231	U
254	0305242M	Unmanned Aerial Systems (UAS) Payloads (MIP)	07	18,392	5,956		5,956	U
255	0305421N	RQ-4 Modernization	07	224,249	219,403		219,403	U
256	0308601N	Modeling and Simulation Support	07	5,038	7,097		7,097	U
257	0702207N	Depot Maintenance (Non-IF)	07	35,463	46,560		46,560	U
258	0708730N	Maritime Technology (MARITECH)	07	4,621	27,284		27,284	U

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241	0303140N	Information Systems Security Program	07	41,853				41,853	U
243	0305192N	Military Intelligence Program (MIP) Activities	07	8,913				8,913	U
244	0305204N	Tactical Unmanned Aerial Vehicles	07	9,451				9,451	U
245	0305205N	UAS Integration and Interoperability	07	42,315				42,315	U
246	0305208M	Distributed Common Ground/Surface Systems	07	22,042				22,042	U
247	0305208N	Distributed Common Ground/Surface Systems	07						U
248	0305220N	MQ-4C Triton	07	11,784				11,784	U
249	0305231N	MQ-8 UAV	07	29,618				29,618	U
250	0305232M	RQ-11 UAV	07	509				509	U
251	0305234N	Small (Level 0) Tactical UAS (STUASL0)	07	11,545				11,545	U
252	0305239M	RQ-21A	07	10,914				10,914	U
253	0305241N	Multi-Intelligence Sensor Development	07	70,612				70,612	U
254	0305242M	Unmanned Aerial Systems (UAS) Payloads (MIP)	07	3,704				3,704	U
255	0305421N	RQ-4 Modernization	07	202,346				202,346	U
256	0308601N	Modeling and Simulation Support	07	7,119				7,119	U
257	0702207N	Depot Maintenance (Non-IF)	07	38,182				38,182	U
258	0708730N	Maritime Technology (MARITECH)	07	6,779				6,779	U

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259	1203109N	Satellite Communications (SPACE)	07	40,330	34,174		34,174	U
9999	9999999999	Classified Programs		1,857,702	1,670,503	117,282	1,787,785	U
		Operational Systems Development		4,347,723	4,913,710	133,412	5,047,122	
Total Research, Development, Test & Eval, Navy				18,465,332	18,490,002	167,812	18,657,814	

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259	1203109N	Satellite Communications (SPACE)	07	15,868				15,868	U
9999	9999999999	Classified Programs		1,613,137		108,282	108,282	1,721,419	U
		Operational Systems Development		5,104,299		123,282	123,282	5,227,581	
Total Research, Development, Test & Eval, Navy				20,270,499		164,410	164,410	20,434,909	

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14	02	0602782N	Mine & Exp Warfare Applied Res	Volume 1 - 225
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20	03	0603651M	JT Non-Lethal Wpns Tech Dev	Volume 1 - 305
21	03	0603673N	(U)Future Naval Capabilities Advanced Tech Dev	Volume 1 - 309
22	03	0603680N	(U)Manufacturing Technology Program	Volume 1 - 325
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JT Non-Lethal Wpns Tech Dev	0603651M	20	03	Volume 1 - 305
JT Precision Approach & Ldg Sys	0603860N	71	04	Volume 2 - 991
JT Service EOD	0604654N	139	05	Volume 3 - 1159
JT Service Explosive Ordn Dev	0603654N	57	04	Volume 2 - 735
JT Strike Fighter (JSF) - EMD	0604800N	150	05	Volume 3 - 1459
JT Tact Radio Sys (JTRS)	0604280N	117	05	Volume 3 - 533
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Joint Air-to-ground Missile (JAGM)	0605450N	164	05	Volume 3 - 1883
Joint Non-Lethal Weapons Testing	0603851M	70	04	Volume 2 - 979
Joint Standoff Weapon Systems	0604727N	142	05	Volume 3 - 1191
LPD-17 Class Systems Integration	0604311N	120	05	Volume 3 - 683
Land Attack Tech	0603795N	69	04	Volume 2 - 955
Lightweight Torpedo Development	0604610N	138	05	Volume 3 - 1133
MC Advanced Technology Demo	0603640M	19	03	Volume 1 - 273
MC Ground Cmbt Spt Arms Sys	0206623M	230	07	Volume 5 - 809
MK-48 ADCAP	0205632N	225	07	Volume 5 - 539
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Marine Corps Comms Systems	0206313M	228	07	Volume 5 - 619
Marine Corps Grnd Cmbt/Supt Sys	0603635M	56	04	Volume 2 - 709
Marine Corps IT Dev/Mod	0605013M	153	05	Volume 3 - 1515
Marine Corps Lndg Force Tech	0602131M	6	02	Volume 1 - 105
Marine Corps Program Wide Supt	0605873M	191	06	Volume 4 - 239
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Medical Development	0604771N	147	05	Volume 3 - 1365
Mine & Exp Warfare Applied Res	0602782N	14	02	Volume 1 - 225
Mine Development	0604601N	137	05	Volume 3 - 1115
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Modeling & Simulation Support	0308601N	256	07	Volume 5 - 1331
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Multi-mssn Maritime Aircraft (MMA) (P-8A)	0605500N	165	05	Volume 3 - 1893
NATO Research and Deve	0603790N	68	04	Volume 2 - 945
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Navy Space & Electr Warfare Supt	0605866N	189	06	Volume 4 - 221
Navy Strategic Comms	0101402N	210	07	Volume 5 - 145
Navy Tactical Computer Resources	0604574N	135	05	Volume 3 - 1095
Navy Warfighting Exp & Demo	0603758N	25	03	Volume 1 - 345
New Design SSN	0604558N	132	05	Volume 3 - 991
Next Generation Jammer (NGJ)	0604274N	116	05	Volume 3 - 519
Ocean Engineering Tech Dev	0603713N	58	04	Volume 2 - 781
Ocean Wrfghtg Env Applied Res	0602435N	10	02	Volume 1 - 173
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Submarine Tactical Warfare System	0604562N	133	05	Volume 3 - 1019
Surface & Shallow Water MCM	0603502N	34	04	Volume 2 - 201
Surface ASW	0603553N	41	04	Volume 2 - 329
Surface ASW Cmbt Sys Integr	0205620N	224	07	Volume 5 - 525
Surface Combatant Cmbt Sys Eng	0604307N	119	05	Volume 3 - 633
Surface Ship Torpedo Defense	0603506N	35	04	Volume 2 - 277
Surface Support	0204228N	213	07	Volume 5 - 229
Tact Air Dir Infrared CM (TADIRCM)	0604272N	82	04	Volume 2 - 1219
Tactical Aim Missiles	0207161N	234	07	Volume 5 - 1067
Tactical Airborne Reconnaissance	0603261N	32	04	Volume 2 - 139
Tactical Command System	0604231N	105	05	Volume 3 - 159
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Tactical Data Links	0205604N	223	07	Volume 5 - 493
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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601103N / *University Research Initiatives*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	137.515	161.433	116.850	-	116.850	116.816	119.141	121.595	124.040	Continuing	Continuing
0000: *University Research Initiatives*	0.000	112.407	119.433	116.850	-	116.850	116.816	119.141	121.595	124.040	Continuing	Continuing
9999: *Congressional Adds*	0.000	25.108	42.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	67.108

A. Mission Description and Budget Item Justification

This program includes support for multidisciplinary basic research in a wide range of scientific and engineering disciplines that enables the U.S. Navy to maintain technological superiority and for the university research infrastructure to acquire the research instrumentation needed to maintain and improve the quality of university research important to the Navy. Multidisciplinary University Research Initiative (MURI) efforts involve teams of researchers investigating high priority topics and opportunities that intersect more than one traditional technical discipline. For many military problems this multidisciplinary approach serves to stimulate innovation, accelerate research progress and expedite transition of results into Naval applications. The Defense University Research Instrumentation Program (DURIP) supports university research infrastructure essential to high quality, Navy-relevant research. The instrumentation program complements other Navy research programs by supporting the purchase of high cost research instrumentation that is necessary to carry out cutting-edge research. The program supports Presidential Early Career Awards for Scientists and Engineers (PECASE), single investigator research efforts performed by outstanding academic scientists and engineers early in their research careers. This program provides the knowledge base, scientific concepts, and technological advances for the maintenance of Naval power and national security.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	118.130	119.433	117.552	-	117.552
Current President's Budget	137.515	161.433	116.850	-	116.850
Total Adjustments	19.385	42.000	-0.702	-	-0.702
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	42.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-1.280	0.000			
• SBIR/STTR Transfer	-5.335	0.000			
• Rate/Misc Adjustments	0.000	0.000	-0.702	-	-0.702
• Congressional Add Adjustments	26.000	-	-	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601103N / *University Research Initiatives*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Program Increase*	9.657	0.000
Congressional Add: *Defense University Research Instrumentation Program*	9.657	10.000
Congressional Add: *Radar Technology*	5.794	6.000
Congressional Add: *Biocoherent Energy*	0.000	6.000
Congressional Add: *Basic Research*	0.000	10.000
Congressional Add: *Aircraft Fleet Readiness and Sustainment*	0.000	10.000
Congressional Add Subtotals for Project: 9999	25.108	42.000
Congressional Add Totals for all Projects	25.108	42.000

Change Summary Explanation

Change from FY 2019 to FY 2020 includes reduced funding for new MURI projects in FY 2020.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601103N / *University Research Initiatives*	Project (Number/Name) 0000 / *University Research Initiatives*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *University Research Initiatives*	0.000	112.407	119.433	116.850	-	116.850	116.816	119.141	121.595	124.040	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project includes support for multidisciplinary basic research in a wide range of scientific and engineering disciplines that are important for maintaining the technological superiority of the U.S. Navy, and for university research infrastructure to acquire instrumentation needed to maintain and improve the quality of university research important to the Navy. MURI efforts involve teams of researchers investigating high priority topics that intersect more than one traditional technical discipline. For many military problems this multidisciplinary approach serves to stimulate innovation, accelerate research progress, and expedite transition of results into Naval applications. The DURIP project supports university research infrastructure essential to high quality, Navy-relevant research. The instrumentation project complements other Navy research programs by supporting the purchase of high cost research
instrumentation that is necessary to carry out cutting-edge research. The PECASE project supports single-investigator research efforts performed by outstanding academic scientists and engineers early in their research careers. This project provides the knowledge base, scientific concepts, and technological advances for the maintenance of Naval power and national security.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: DEFENSE UNIVERSITY RESEARCH INSTRUMENTATION PROGRAM (DURIP)	21.925	23.774	23.266	0.000	23.266
Description: DURIP funds are provided to universities to purchase relatively high cost research instrumentation that is normally not included in single-investigator type research grants. Individual grants range from $50K to $1.5M. Funding for DURIP efforts be awarded after the Office of the Secretary of Defense (OSD) announces the awardees, which typically takes place towards the second half of the fiscal year. In turn, universities need to purchase the instrumentation and take delivery before any billings are generated. It frequently takes several months for delivery and billing to be completed. DURIP is a one-year program.					
FY 2019 Plans: Continue to support university research infrastructure essential to high-quality naval-relevant research.					
FY 2020 Base Plans: Provide funding for instrumentation to enhance basic research, such as: human-machine interfaces, basic research on communications and networks, basic research on power generation and storage, basic research on high-performance materials, and basic research in the ocean sciences and underwater acoustics. Implement the instrumentation investments made for research efforts, such as: transmission electron microscopy, infrared optoelectronic measurements, an underwater acoustic communication system, basic thermal property					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601103N / *University Research Initiatives*	**Project (Number/Name)** 0000 / *University Research Initiatives*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
measurements, cardiorespiratory physiology phenotyping, and high-speed stereographic imaging for multiphase flows. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: MULTIDISCIPLINARY UNIVERSITY RESEARCH INITIATIVE (MURI) ***Description:*** Research efforts include high priority topics that intersect more than one traditional discipline. MURI topics are selected to address Naval Science and Technology (S&T) Framework Priorities as described in the Naval Research and Development Framework. Funding for MURI efforts are awarded after OSD announces the awardees, which typically takes place towards the second half of the fiscal year. Since the MURI program funds academic researchers, execution of the efforts typically ramp up during the summer academic break months. MURI projects make significant contributions to Navy and DoD objectives by speeding up scientific programs, by cross-fertilization of ideas, by hastening the transition of basic research to practical applications, and by training students in cross-disciplinary approaches to science and engineering research of importance to DoD. MURI projects are five year programs. ***FY 2019 Plans:*** Continue to support teams of researchers investigating high priority topics and opportunities thru competition for new MURI awards to address selected high priority Naval S&T areas, transformational initiatives, and grand challenges, including strategically important DoD research areas that intersect more than one traditional technical discipline. ***FY 2020 Base Plans:*** The MURI program will support multidisciplinary basic research topics, such as: the role of epigenetics in human performance, research on understanding scenes and events through joint parsing, cognitive reasoning and lifelong learning, research on bio-inspired adaptive sonar for classification and guidance in complex environments, research on neural circuits underlying symbolic processing in primate cortex and basal ganglia, and research on chemistry and physics at extreme temperature and pressure: molecules, crystals and microstructures. These investigations support high	82.224	86.706	84.823	0.000	84.823

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601103N / *University Research Initiatives*	**Project (Number/Name)** 0000 / *University Research Initiatives*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
priority topics and scientific opportunities to address strategically important Department of Defense (DoD) research areas that intersect more than one traditional technical discipline. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The MURI funding decrease from FY 2019 to FY 2020 will be reflected in fewer new MURI projects.					
Title: PRESIDENTIAL EARLY CAREER AWARDS (PECASE) ***Description:*** PECASE awards are made to academic scientists early in their research careers for extremely prestigious, single-investigator research in areas of vital importance to the Navy. Awards provide national recognition and research grants of up to $200K per year for five years. OSD, with policy and oversight responsibility for the PECASE program, awards a minimum of four new awards per year. PECASE is a five year program. ***FY 2019 Plans:*** Continue to award four new awards for recognizing and honoring extraordinary achievements of young professionals at the outset of their independent research careers in Science and Technology. ***FY 2020 Base Plans:*** The program will support early career investigators in research areas within the Navy Research and Development (R&D) framework priority objectives, such as: the design of an end-to-end protocol for dynamic spectrum access networks; the determination of multiscale interactions in tropical cyclone structure and intensity changes; the engineering of nonreciprocal acoustic materials and microwave systems through phonon-assisted directional coupling; and the development of therapeutic hydrogel sensors for the monitoring and treatment of wounds. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020	8.258	8.953	8.761	0.000	8.761
Accomplishments/Planned Programs Subtotals	112.407	119.433	116.850	0.000	116.850

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601103N / *University Research Initiatives*	**Project (Number/Name)** 0000 / *University Research Initiatives*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

This University Research Initiative seeks to improve the quality of defense research conducted by universities and supports the education of engineers and scientists in disciplines critical to national defense needs. The initiative is a collection of specialized research programs performed by academic research institutions. Individual project metrics are tailored to the needs of specific applied research and advanced development programs. Example metrics include extending the life of Thermal Barrier Coatings for transition to the Enterprise and Platform Enablers Future Naval Capability program. It is projected that the life time of Thermal Barrier Coating on Turbine Blades can be doubled. The National Research Council of the National Academies of Science and Engineering's Congressionally directed "Assessment of Department of Defense Basic Research" concluded that the DoD is managing its basic research program effectively.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319 / 1					R-1 Program Element (Number/Name) PE 0601103N / *University Research Initiatives*				Project (Number/Name) 9999 / *Congressional Adds*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
9999: *Congressional Adds*	0.000	25.108	42.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	67.108

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Program Increase	9.657	0.000
FY 2018 Accomplishments: This increase furthered the U. S. Navy's efforts to support multidisciplinary basic research in a wide range of scientific and engineering disciplines that enable the U.S. Navy to maintain its technological superiority. Through this increase, additional Multidisciplinary University Research Initiative (MURI) awards, and Presidential Early Career Awards for Scientists and Engineers (PECASE) were selected and funded. These new MURI topics draw from the most critical Naval R&D priorities to translate future force attributes into research objectives. Outstanding young PECASE scientists and engineers were be funded to address shared Naval R&D priorities. These research objectives include improving human-machine interfaces, increasing the flexibility and reach of the naval force through the incorporation of autonomous systems, enabling maneuverability, efficiency and resiliency for sustained operations, transforming vast data into timely knowledge; and enabling offensive and defensive actions that are multi-domain, integrated, and cost-effective.		
FY 2019 Plans: N/A		
Congressional Add: Defense University Research Instrumentation Program	9.657	10.000
FY 2018 Accomplishments: Through this increase, additional Defense University Research Instrumentation Program (DURIP) awards were selected and funded enabling the performers to take advantage of the evolving technological advances in scientific instrumentation to study the physical, chemical, geological, and geophysical processes of the oceans, so that research can continue to keep pace with the Science and Technology (S&T) Community. The oceans are the primary Navy-relevant operational environment and ocean research requires specialized sea-going, resilient marine equipment.		
FY 2019 Plans: Through this increase, additional Defense University Research Instrumentation Program (DURIP) awards will be selected and funded enabling the performers to take advantage of the evolving technological advances in scientific instrumentation to study the physical, chemical, geological, and geophysical processes of the oceans, so that research can continue to keep pace with the Science and Technology (S&T)		

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601103N / *University Research Initiatives*	**Project (Number/Name)** 9999 / *Congressional Adds*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Community. The oceans are the primary Navy-relevant operational environment and ocean research requires specialized sea-going, resilient marine equipment.		
Congressional Add: Radar Technology ***FY 2018 Accomplishments:*** Conducted efforts that seek to leverage advances in the field of radar development with respect to incorporating both polarimetric and phased array radar technology in an all-digital design for new technology to assist the Navy with improved weather forecasting. ***FY 2019 Plans:*** Conduct efforts for the design, construction and testing of a mobile, ground-based, active aperture array (active electronically scanned antenna - AESA) utilizing cutting-edge science and technology for critical aperture components (receiver and transmitter).	5.794	6.000
Congressional Add: Biocoherent Energy ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Basic science research to identify mechanisms to enhance coherent energy transfer between photoactive molecules attached to nucleic acid nanostructures for application to synthetic light harvesting systems, optoelectronic devices, information processing systems, and possibly quantum computing. - AIM 1: Conduct and develop computational and experimental approaches to identify the best structures of photoactive molecules and their nucleic acid nanostructures that can efficiently transfer energy coherently. - AIM2: Assemble the superior photoactive molecules into structures using nucleic acid self-assembly and assess performance.	0.000	6.000
Congressional Add: Basic Research ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** This increase furthers the U. S. Navy's efforts to support multidisciplinary basic research in a wide range of scientific and engineering disciplines that enable the U.S. Navy to maintain its technological superiority. Through this increase, additional Multidisciplinary University Research Initiative (MURI) awards, and Presidential Early Career Awards for Scientists and Engineers (PECASE) will be selected and funded. These new MURI topics draw from the most critical Naval R&D priorities to translate future force attributes into research objectives. Outstanding young PECASE scientists and engineers were be funded to address shared Naval R&D priorities. These research objectives include improving human-machine interfaces, increasing the flexibility and reach of the naval force through the incorporation of autonomous systems, enabling maneuverability,	0.000	10.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601103N / *University Research Initiatives*	**Project (Number/Name)** 9999 / *Congressional Adds*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
efficiency and resiliency for sustained operations, transforming vast data into timely knowledge; and enabling offensive and defensive actions that are multi-domain, integrated, and cost-effective.		
Congressional Add: Aircraft Fleet Readiness and Sustainment ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Basic research focus on advanced laboratory equipment and capabilities in support of Aviation Structures.	0.000	10.000
Congressional Adds Subtotals	25.108	42.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other Projects.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601152N / *In-House Lab Independent Res*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	19.035	19.237	19.121	-	19.121	19.113	19.492	19.895	20.295	Continuing	Continuing
0000: *In-House Lab Independent Res*	0.000	19.035	19.237	19.121	-	19.121	19.113	19.492	19.895	20.295	Continuing	Continuing

A. Mission Description and Budget Item Justification

This Program Element (PE) includes scientific study and experimentation directed toward increasing knowledge and understanding in national-security related aspects of physical, engineering, environmental, and life sciences, and is the core of Discovery and Invention. Basic research projects are developed, managed, and related to more advanced aspects of research in technology and capability-related 'thrusts' which are consolidated in thirteen Naval Research and Development Framework focus areas: Power and Energy; Operational Environments; Maritime Domain Awareness; Asymmetric and Irregular Warfare; Information, Analysis and Communication; Power Projection; Assure Access and Hold at Risk; Distributed Operations; Naval Warfighter Performance and Protection; Survivability and Self-Defense; Platform Mobility; Fleet/Force Sustainment; Affordability, Maintainability and Reliability.

The In-House Laboratory Independent Research Program provides participating Naval Warfare Centers and Laboratories with funding for: basic research to develop and maintain a cadre of active researchers who can distill and extend results from worldwide research and apply them to solve Naval problems; promoting hiring and development of new scientists; and encouragement of collaboration with universities, private industry, and other Navy and Department of Defense laboratories.

ILIR efforts are selected by Naval Warfare Centers/Lab Commanding Officers and Technical Directors near the start of each Fiscal Year through internal competition. Efforts typically last three years, and are generally designed to assess the promise of new lines of research. Successful efforts attract external, competitively awarded funding. Because the Warfare Centers and Labs encompass the full range of naval technology interests, the scope of ILIR topics roughly parallels that of PE 0601153N, Defense Research Science.

This PE sustains U.S. Naval Science and Technology (S&T) superiority by providing new technological concepts for the maintenance of Naval power and national security, by helping to avoid scientific surprise while exploiting scientific breakthroughs, and by providing options for new Future Naval Capabilities (FNCs). The research aligns to the Naval Research and Development Framework for long term Navy and Marine Corps improvements and is in consonance with future warfighting concepts and doctrine developed at the Naval Warfare Development Command and the Marine Corps Combat Development Command. It enables technologies that significantly improve the Joint Chiefs of Staff's Future Joint Warfighting Capabilities. The In-house Laboratory Independent Research (ILIR) program also adds increased emphasis to the revitalization of the scientist and engineer workforce component at the Navy's Warfare Centers and Laboratories by attracting superior candidates and retaining our best members through the provision of exciting and meaningful work.

Due to the number of efforts in PE 0601152N, the programs described herein are representative of the work included in this PE.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy					Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy* / BA 1: *Basic Research*			R-1 Program Element (Number/Name) PE 0601152N / *In-House Lab Independent Res*		
B. Program Change Summary ($ in Millions)	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**
Previous President's Budget	19.438	19.237	19.235	-	19.235
Current President's Budget	19.035	19.237	19.121	-	19.121
Total Adjustments	-0.403	0.000	-0.114	-	-0.114
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.288	0.000			
• SBIR/STTR Transfer	-0.115	0.000			
• Rate/Misc Adjustments	0.000	0.000	-0.114	-	-0.114

Change Summary Explanation

There is no significant change from FY 2019 to FY 2020.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601152N / *In-House Lab Independent Res*	Project (Number/Name) 0000 / *In-House Lab Independent Res*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *In-House Lab Independent Res*	0.000	19.035	19.237	19.121	-	19.121	19.113	19.492	19.895	20.295	Continuing	Continuing

A. Mission Description and Budget Item Justification

The In-House Laboratory Independent Research Program provides participating Naval Warfare Centers and Laboratories with funding for: basic research to develop and maintain a cadre of active researchers who can distill and extend results from worldwide research and apply them to solve Naval problems; promoting hiring and development of new scientists; and encouragement of collaboration with universities, private industry, and other Navy and Department of Defense laboratories.

This project sustains U.S. Naval S&T superiority, provides new technological concepts for the maintenance of naval power and national security, and mitigates scientific surprises, while exploiting scientific breakthroughs and providing options for new Future Naval Capabilities. It addresses the S&T research areas of the Naval Research and Development Framework for long term Navy and Marine Corps improvements. It is in consonance with future warfighting concepts and doctrine developed at the Naval Warfare Development Command and the Marine Corps Combat Development Command and enables technologies that significantly improve the Joint Chiefs of Staff's Future Joint Warfighting Capabilities.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: IN-HOUSE LABORATORY INDEPENDENT RESEARCH (ILIR)	16.523	16.690	16.588	0.000	16.588
FY 2019 Plans: Continue In-house Laboratory Independent Research (ILIR) projects which enables laboratories to sponsor focused, high-risk/potential high reward basic research to the Navy and Marine Corps on a discretionary basis. Each project is funded for at most three years with the goal being to transition successful technologies to either a higher level of research or to a program of record.					
FY 2020 Base Plans: Provide funding for ILIR program which enables laboratories to sponsor focused, high-risk/potential high reward basic research to the Navy and Marine Corps on a discretionary basis. Each project is funded for at most three years with the goal being to transition successful technologies to either a higher level of research or to a program of record. Approximately 120 projects will be funded all aligned with the Research and Development (R&D) framework focus areas.					
FY 2020 OCO Plans: N/A					
FY 2019 to FY 2020 Increase/Decrease Statement:					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601152N / *In-House Lab Independent Res*	**Project (Number/Name)** 0000 / *In-House Lab Independent Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
There is no significant change from FY 2019 to FY 2020.					
Title: SCIENCE TECHNOLOGY ENGINEERING AND MATH (STEM) EFFORTS AT NAVY LABS	2.512	2.547	2.533	0.000	2.533
Description: This effort will support both the Science and Engineering Apprenticeship Program (SEAP) and the Naval Research Enterprise Intern Program (NREIP) summer programs to encourage participating students to pursue science and engineering careers, to further their education via mentoring by laboratory personnel and their participation in research, and to make them aware of Department of the Navy (DON) research and technology efforts, which can lead to employment within the DON. Participating students will spend eight to ten weeks during the summer doing research at approximately 19 to 20 DON laboratories. Participants will receive a stipend distributed by the Contractor. The stipend is a monthly allowance paid to interns for their participation in the research efforts. ***FY 2019 Plans:*** Continue to provide opportunities for approximately 300 high school and 600 college and graduate students to participate in research at DON laboratories during the summer via the NREIP program for undergraduate and graduate students and the SEAP Program for high school students. ***FY 2020 Base Plans:*** Provide opportunities for approximately 300 high school students and 600 college students, both undergraduate and graduates, to participate in research at multiple Department of Navy Laboratories during the summer via the NREIP for undergraduate and graduate students and the SEAP for high school students. These paid internships last between 8-10 weeks. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Accomplishments/Planned Programs Subtotals	19.035	19.237	19.121	0.000	19.121

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601152N / *In-House Lab Independent Res*	**Project (Number/Name)** 0000 / *In-House Lab Independent Res*

D. Acquisition Strategy

Not applicable.

E. Performance Metrics

The In-house Laboratory Independent Research initiative seeks to improve the quality of defense research conducted predominantly through the Naval Warfare Centers/ Laboratories. It also supports the development of technical intellect and education of engineers and scientists in disciplines critical to national defense needs through the development of new knowledge in a military laboratory environment. Initial research focus is often conducted in an unfettered environment since it is basic research, but many projects focus on applying recently developed theoretical knowledge to real world military problems with the intention of developing new capabilities and improving the performance of existing systems. Individual project metrics then become more tailored to the needs of specific applied research and advanced development programs. The National Research Council of the National Academies of Science and Engineering's Congressionally directed "Assessment of Department of Defense Basic Research" concluded that the Department of Defense is managing its basic research program effectively.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601153N *I Defense Research Sciences*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	448.084	499.102	470.007	-	470.007	472.158	483.223	492.588	502.242	Continuing	Continuing
0000: *Defense Research Sciences*	0.000	448.084	458.602	470.007	-	470.007	472.158	483.223	492.588	502.242	Continuing	Continuing
9999: *Congressional Adds*	0.000	0.000	40.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	40.500

A. Mission Description and Budget Item Justification

This Program Element (PE) addresses basic research efforts including scientific study and experimentation directed toward increasing knowledge and understanding in national security related aspects of physical, engineering, environmental and life sciences. Basic research efforts are developed, managed, and related to more advanced aspects of research on the order of a hundred technology and capability-related 'thrusts', which are consolidated into about fifteen research areas. These in turn support the major research areas of the Navy and Marine Corps: Autonomous Systems; Artificial Intelligence/Machine Learning; Command, Control, Communications and Computers (C4); Marine as a System; Information Analysis and Decision Support; Intelligence, Surveillance and Reconnaissance; Logistics; Materials; Operational Environments; Platforms; Power and Energy Technology; Sensors and Electronics; Warrior Performance and Protection; Weapons and Support (Education and Outreach).

This PE sustains U.S. Naval Science and Technology (S&T) superiority, provides new technological concepts for the maintenance of naval power and national security, and helps avoid scientific surprise. It is based on investment directions as defined in the Naval Research and Development Framework. This strategy is based on needs and capabilities from Navy and Marine Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It exploits scientific breakthroughs and provides options for new Future Naval Capabilities (FNCs) and Innovative Naval Prototypes (INPs).

S&T investment in basic research also includes the National Naval Responsibilities (NNRs), fields upon which a wide range of fundamental Naval capabilities depend. There are currently five NNRs.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601153N / *Defense Research Sciences*

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	458.333	458.708	456.885	-	456.885
Current President's Budget	448.084	499.102	470.007	-	470.007
Total Adjustments	-10.249	40.394	13.122	-	13.122
• Congressional General Reductions	-	-0.106			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	40.500			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-10.176	0.000			
• Program Adjustments	0.000	0.000	15.000	-	15.000
• Rate/Misc Adjustments	0.000	0.000	-1.878	-	-1.878
• Congressional General Reductions Adjustments	-0.073	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Basic Research*	0.000	35.000
Congressional Add: *Navy ROTC Cybersecurity Training Program*	0.000	5.500
Congressional Add Subtotals for Project: 9999	0.000	40.500
Congressional Add Totals for all Projects	0.000	40.500

Change Summary Explanation

The program increase in FY 2020 is a associated with the Science and Technology investment in the development of naval application of artificial intelligence (AI).

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 1	R-1 Program Element (Number/Name) PE 0601153N / *Defense Research Sciences*	Project (Number/Name) 0000 / *Defense Research Sciences*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *Defense Research Sciences*	0.000	448.084	458.602	470.007	-	470.007	472.158	483.223	492.588	502.242	Continuing	Continuing

A. Mission Description and Budget Item Justification

This Program Element (PE) addresses basic research efforts including scientific study and experimentation directed toward increasing knowledge and understanding in national security related aspects of physical, engineering, environmental and life sciences. Basic research efforts are developed, managed, and related to more advanced aspects of research on the order of a hundred technology and capability-related 'thrusts', which are consolidated into about fifteen research areas. These in turn support the major research areas of the Navy and Marine Corps: Autonomous Systems; Command, Control, Communications and Computers (C4); Marine as a System; Information Analysis and Decision Support; Intelligence, Surveillance and Reconnaissance; Logistics; Materials; Operational Environments; Platforms; Power and Energy Technology; Sensors and Electronics; Warrior Performance and Protection; Weapons and Support. Activities in this area also support maintenance of the Science and Engineering Workforce and STEM Education and Outreach.

This PE sustains U.S. Naval Science and Technology (S&T) superiority, provides new technological concepts for the maintenance of naval power and national security, and helps avoid scientific surprise. It is based on investment directions as defined in the Naval Science & Technology Strategy. This strategy is based on needs and capabilities from Navy and Marine Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It exploits scientific breakthroughs and provides options for new Future Naval Capabilities (FNCs) and Innovative Naval Prototypes (INPs).

S&T investment in basic research also includes the National Naval Responsibilities (NNRs), S&T areas that are uniquely important to maintaining U.S. Naval superiority. With the designation in 2011 of Sea-Based Aviation as an NNR, there are currently five NNRs.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: AIR, GROUND AND SEA VEHICLES	55.882	57.754	56.469	0.000	56.469
Description: Efforts include research in surface/subsurface signatures; free-surface, subsurface, and propulsor hydromechanics; hull life assurance; advanced ship concepts; distributed intelligence for automated survivability; advanced electrical power systems; air vehicles; air platforms propulsion and power; air platforms survivability and signature control; special aviation projects; Unmanned Air Vehicle/Unmanned Combat Air Vehicle (UAV/ UCAV); environmental quality; logistics; power generation, energy conversion, and storage; and advancements in naval technology innovations.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601153N / *Defense Research Sciences*	**Project (Number/Name)** 0000 / *Defense Research Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Accomplishments and plans described below are examples for each effort category. ***FY 2019 Plans:*** Air Vehicles Continue Basic research investments include fixed-wing, rotary wing, and vertical/short takeoff and landing (V/STOL) aircraft, ship/aircraft dynamic interface, air vehicle management, and control, aerodynamics, and aeromechanics. Additional research investments include airframe structures and materials science address durability, service life, readiness, affordability, and future capabilities development. Most airframe challenges are not platform or design specific; they are fully represented in both current new-build and planned next-generation platform designs. Additional areas of research include metallic structures and materials, composite structures and materials, and advanced concepts related to: design, failure analysis, materials selection, fabrication, and sustainment of air-vehicle structures. Conducting university research supports rotorcraft technology areas such as tilt rotor aeromechanics, rotor flow field/ship air wake coupling during shipboard operations, flight simulation of advanced ducted fan air vehicles, active rotor control for enhanced shipboard operations, autonomous rotorcraft operations in shipboard environment, and innovative rotor design concepts for naval applications. Continuing Sea-Based Aviation National Naval Responsibility (NNR) research in Virtual Dynamic Interface (VDI), advanced manned/unmanned handling qualities and control for Naval operations, improved fixed wing launch and recovery high lift aerodynamics and performance, Enhanced fixed wing V/STOL operations, and autonomous deck operations. Continuing SBA Structures and Materials NNR research for advanced airframes in metallic structures, combined loading mechanics, lightweight advanced polymer and ceramic composites, inspection and repair of composite structures, material coatings and sealants, and advanced concepts in manufacturing and multifunctional structures. Science of Autonomy Continue basic research related to critical multidisciplinary autonomy challenges that cut across areas/domains, including air, sea, undersea and ground. This includes multi-disciplinary research into the science of autonomy focuses on four interrelated areas: scalable and robust distributed collaboration among autonomous systems; human/unmanned system collaboration; autonomous perception and intelligent decision-making; and intelligent architectures for autonomous systems. Advanced Naval Power Systems					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601153N / *Defense Research Sciences*	**Project (Number/Name)** 0000 / *Defense Research Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Conduct basic research related to critical S&T to investigate efforts related to thermal science and engineering; power electronics/electro-magnetics; and energy conversion, storage and generation. Pursue research in computer-aided material design; scarce materials mitigation strategies; electrochemical materials; and functional polymeric materials. Advanced Sea Platform Performance Conduct basic research related to critical S&T to investigate efforts related to propulsor, surface ship, and subsurface hydrodynamics; platform mobility; alternative hull materials; and structural acoustics. Expand research related to naval engineering and platform design, including Ohio Replacement Program efforts, and centers for innovative naval technology. Sea Platform Survivability Science Conduct basic research related to critical S&T to investigate efforts related to platform structural reliability; advanced control; acoustic and non-acoustic (electromagnetic) signatures; computational mechanics; metamaterials; and multihull design and optimization. Materials, Coatings and Corrosion Control Science Conduct basic research related to critical S&T to investigate corrosion control technologies. Pursue research in identifying new materials and coatings for naval applications. Ship and Air Platform Machinery and Systems Continue basic research to advance the technical superiority of Sea-Based Aviation Science and Technology NNR in propulsion, power and thermal management related technologies with emphasis on propulsion cycles, subsystems, and integration, turbo machinery and drive systems, jet noise reduction, hot section materials and coatings, and small UAV propulsion. Conduct research to improve the power density, fuel efficiency, range and operating reliability of future large, medium and small engines. Continue studies to obtain a better fundamental understanding of the technologies involved with Rotating Detonation Engines and integration into platforms and weapon systems using thermodynamic models, Computational Fluid Dynamics and sub-scale experiments. Pursue research for better fundamental understanding of the underlying physics of jet noise production from multi-stream, hot, supersonic jets, and control schemes through fundamental modeling of unsteady and turbulent					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601153N / *Defense Research Sciences*	**Project (Number/Name)** 0000 / *Defense Research Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
flow fields and development of more accurate and efficient computational tools. Continue basic research to improve jet engine material durability and temperature and temperature rate capabilities in both benign and corrosive environments. Increase the technical maturity of lightweight ceramic heat exchangers for small engines.with no new efforts identified. ***FY 2020 Base Plans:*** Air Vehicles Basic research investments include fixed-wing, rotary wing, and vertical/short takeoff and landing (V/STOL) aircraft, ship/aircraft dynamic interface, air vehicle management, and control, aerodynamics, and aeromechanics. Additional research investments include airframe structures and materials science address durability, service life, readiness, affordability, and future capabilities development. Most airframe challenges are not platform or design specific; they are fully represented in both current new-build and planned next-generation platform designs. Additional areas of research include metallic structures and materials, composite structures and materials, and advanced concepts related to: design, failure analysis, materials selection, fabrication, and sustainment of air-vehicle structures. Conducting university research supports rotorcraft technology areas such as tilt rotor aeromechanics, rotor flow field/ship air wake coupling during shipboard operations, flight simulation of advanced ducted fan air vehicles, active rotor control for enhanced shipboard operations, autonomous rotorcraft operations in shipboard environment, and innovative rotor design concepts for naval applications. Continuing Sea-Based Aviation National Naval Responsibility (NNR) research in Virtual Dynamic Interface (VDI), advanced manned/unmanned handling qualities and control for Naval operations, improved fixed wing launch and recovery high lift aerodynamics and performance, Enhanced fixed wing V/STOL operations, and autonomous deck operations. Continuing SBA Structures and Materials NNR research for advanced airframes in metallic structures, combined loading mechanics, lightweight advanced polymer and ceramic composites, inspection and repair of composite structures, material coatings and sealants, and advanced concepts in manufacturing and multifunctional structures. Science of Autonomy and Control of Unmanned Systems Conduct basic research related to critical multidisciplinary autonomy and unmanned systems challenges that cut across areas/domains, including air, sea, undersea and ground. This includes multi-disciplinary research into the science of autonomy and unmanned control and focuses on four interrelated areas: scalable and robust distributed collaboration among autonomous or unmanned systems; human/unmanned system collaboration; autonomous perception and intelligent decision-making; and intelligent architectures for autonomous systems.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601153N / *Defense Research Sciences*	**Project (Number/Name)** 0000 / *Defense Research Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Science of Advanced Naval Power and Energy Systems Conduct basic research related to critical S&T to investigate efforts related to thermal science and engineering; power electronics/electro-magnetics; distribution and control of power; power management; and energy conversion, storage and generation. Pursue research in computer-aided material design; scarce materials mitigation strategies; electrochemical materials; and functional polymeric materials, leading to technological underpinnings for advanced energy capture and power storage and distribution. Science of Advanced Naval Platform Performance Conduct basic research related to critical S&T to investigate efforts related to propulsor, surface, and subsurface hydrodynamics; platform dynamics and performance; alternative hull materials; structural acoustics; and submarine security. Expand research related to naval engineering, platform design, and multiple platform control, including COLUMBIA CLASS Program, SSN(X), unmanned surface vessels, and swarm boats efforts, and support to the centers for innovative naval technology. Sea Platform Survivability Science Conduct basic research related to critical S&T to investigate efforts related to platform structural reliability; acoustic and non-acoustic (electromagnetic) signatures; computational mechanics and signatures; metamaterials; and digital ship design and optimization, and improving the understanding of the generation, radiation, propagation, scatter, and detection of a variety of signal types (acoustic, chemical, optical, electromagnetic, hydrodynamic and radiological) associated with a submarine's operation. Materials & Coatings Science Pursue research in identifying new nanostructured materials and coatings processing, ultimately for naval applications. Corrosion Control Science Conduct basic research related to critical S&T to investigate corrosion control technologies. Ship and Air Platform Machinery and Systems Conduct basic research to advance the technical superiority of Sea-Based Aviation Science and Technology NNR in propulsion, power and thermal management related technologies with emphasis on propulsion cycles, subsystems, and integration, turbo machinery and drive systems, jet noise reduction, hot section materials and coatings, and small UAV propulsion. Conduct research to improve the power density, fuel efficiency, range and operating reliability of future large, medium and small engines. Continue studies to obtain a better fundamental					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601153N / *Defense Research Sciences*	**Project (Number/Name)** 0000 / *Defense Research Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
understanding of the technologies involved with Rotating Detonation Engines and integration into platforms and weapon systems using thermodynamic models, Computational Fluid Dynamics and sub-scale experiments. Pursue research for better fundamental understanding of the underlying physics of jet noise production from multi-stream, hot, supersonic jets, and control schemes through fundamental modeling of unsteady and turbulent flow fields and development of more accurate and efficient computational tools. Continue basic research to improve jet engine material durability and temperature and temperature rate capabilities in both benign and corrosive environments. Increase the technical maturity of lightweight ceramic heat exchangers for small engines with no new efforts identified. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** Funding decrease from FY 2019 to FY 2020 IS due to Basic Catalysis research from this R2 Activity being conducted out of R2 Activity Science and Engineering Education, Career Development and Outreach.					
Title: ATMOSPHERE AND SPACE SCIENCES	24.976	25.777	25.899	0.000	25.899
Description: Efforts include: Marine Meteorology and Prediction, and Space Sciences. This program supports innovative basic research on physical process studies, fundamental observations, new sources of data, and modeling in the atmosphere and space with the goal of improving predictive capabilities in the major research area of Operational Environments. Emphasis is placed on the marine atmosphere, the tropics, polar regions, the ionosphere and other areas where new understanding is needed in order to overcome predictability barriers that limit the accuracy of current forecast models. Efforts are underway to understand the interactions of physics between the atmosphere, space, land, ocean and ice, represent these coupled processes in models, and extend them across scales from local to planetary, with the goal extending the skill of predictions to longer timescales (i.e. seasonal to interannual). Recent efforts have also focused on the processes that control tropical cyclone formation, structure and intensity changes and phenomena that affect electromagnetic and electro-optic propagation in the marine atmosphere. Accomplishments and plans described below are examples for each effort category. Accomplishments and plans described below are examples for each effort category. The program is strongly aligned with the Oceanographer of the Navy and the research topics addressed by this sub activity reflects the priorities for improved forecasts of the operational environment and the development and use of autonomous systems for the collection of environmental observations and continuing support to research vessels of the U.S. Academic Research Fleet for operations and maintenance that enable science at sea.This Program requires field research that involves participation in Navy environmental planning efforts					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
including environmental planning documents (Environmental Impact Statements). The use of active acoustic transmissions requires modeling of the acoustic effects of sound on marine life. ***FY 2019 Plans:*** The overall objective of this research is to improve the quality of the atmospheric and space environmental products that are provided to the warfighter and to allow accurate assessment of the impact of space and atmospheric phenomena on the performance of weapon systems. These objectives require advancing our basic understanding of atmospheric and space processes ranging from space to the sea surface, including interactions of the atmosphere with the land, sea, wave, and ice. Battlespace Environments Navy operations in the littoral zone are affected by complex topography and air-sea-land contrasts and phenomena occurring on very short time and space scales. Clouds and moisture phenomena require further study to improve their representation in models. Non-conventional observational data sources require new and novel data assimilation methodologies to be developed before their potential is fully realized. Systems are being employed which operate in or through the earth's upper troposphere, middle and upper atmosphere and the near space environment where environmental supports are crude or non-existent. The interface between the troposphere and stratosphere is gaining increased attention because of its possible effect upon medium term weather prediction. Marine Meteorology and Prediction Research initiatives to improve the sub-grid scale parameterization of clouds, radiation and mixing in the marine boundary layer that developed several innovative new "scale-aware" parameterizations; transition these to applied research and, in one case, directly into a new version of the Navy's global numerical weather prediction system (NAVGEM), which resulted in a major improvement of several objective measures of predictive skill related to clouds and precipitation over the oceans. High-altitude airborne field experiments over major hurricanes during which an unprecedented set of high-resolution soundings covering the full depth of the storms will be obtained that allow detailed physical processes to be observed for the first time. These results will be analyzed, applied to existing models and have demonstrated the potential to make a substantial improvement in the ability to predict intensity and structure change in tropical cyclones. Space Research					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Perform best-in-class, experimentally-led sensing research and development (R&D) that is integrated across three environmental areas -- geospace, heliospace, and high-energy space -- which underpin, connect, and inform successful operations, with metrics to increase technology readiness towards rapidly prototyping solutions for accelerated delivery. Geospace research could include Remove key scientific and computational impediments to a future physics-based Navy ionospheric prediction capability recently identified as a critical capability gap for high frequency (HF) radio-wave technologies for electromagnetic maneuver warfare, by means of focused scientific research on identification of which key drivers from the lower atmosphere and thermosphere are necessary to achieve short term forecasts of HF propagation globally. Heliospace efforts may advance our understanding of solar magnetic fields and how they influence the near-earth environment. High-energy space development will assist in understanding particle acceleration mechanisms in high energy solar flares by studying gamma-ray and neutron emissions that are measured in space. Space Sciences On-going investigation to assimilate observations into space weather models, with an eventual goal of a prediction system that could provide detection and warnings of tsunamis as a variety of observational systems will be utilized to increase the understanding of the physics of ionospheric irregularities and other space weather phenomena. Recent observations have shown that a number of phenomena, including tsunamis, can generate acoustic gravity waves that have an airglow signature in the thermosphere/ionosphere. ***FY 2020 Base Plans:*** The overall objective of this research is to improve the quality of the atmospheric and space environmental products that are provided to the warfighter and to allow accurate assessment of the impact of space and atmospheric phenomena on the performance of weapon systems. These objectives require advancing our basic understanding of atmospheric and space processes ranging from the surface to space, including interactions of the atmosphere with the land, sea, waves, and ice. Battlespace Environments Navy operations in the littoral zone are affected by complex topography and air-sea-land contrasts and phenomena occurring on very short time and space scales. Research is supported to investigate key physical processes, clouds					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
and moisture phenomena in order to improve their representation in models. Efforts are focused on those phenomena that affect the predictability of parameters of most relevance to Naval operations (e.g. coastal meteorology,surface winds, visibility, refractivity, etc.). New and non-conventional observational data sources are explored through efforts that develop novel data assimilation methodologies in order to realize the full potential of such observations. Systems are being employed which operate in or through the earth's upper troposphere, middle and upper atmosphere and the near space environment where environmental supports are crude or non-existent,thus, efforts are supported that seek to extend the range of prediction systems to much higher altitudes. Research is supported to improve understanding of the physics of the upper atmosphere and ionosphere, and to improve the representation of the interface between the troposphere and stratosphere because of its effects upon medium term weather prediction. Marine Meteorology and Prediction Research initiatives to improve the sub-grid scale parameterization of clouds, radiation and mixing in the marine boundary layer that developed several innovative new "scale-aware" parameterizations; transition these to applied research and directly into a new version of the Navy's global numerical weather prediction system (NAVGEM). This activity is scheduled to be completed in FY 2020. High-altitude airborne field experiments over major hurricanes during which an unprecedented set of high-resolution soundings covering the full depth of the storms were obtained allowed detailed physical processes to be observed for the first time.This activity is scheduled to be completed in FY 2020. Results from airborne observations over tropical cyclones will be analyzed and applied to new and existing models to make a substantial improvement in the skill for predicting intensity and structure change in tropical cyclones. Atmospheric process research will seek to advance our understanding of atmospheric and space processes ranging from the surface to space. This includes marine boundary layer physics, air-sea-wave-ice coupling, processes affecting electro-optic and electromagnetic propagation, and better representation of clouds and moisture in numerical weather prediction models. A new research initiative will be initiated to focus on the origin, evolution and effects of Arctic cyclones that are poorly predicted but are believed to have a strong influence on Arctic ice. Airborne observations over the Arctic from high-altitude research aircraft will be used to investigate processes from the stratosphere to the surface in order to improve their representation in numerical weather prediction models that can be coupled to the physics of the ocean and ice. Space Research					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
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Title: SCIENCE ADDRESSING HYBRID THREATS	23.166	23.729	25.823	0.000	25.823
Description: The Sciences Addressing Hybrid Threats (SAHT) (formerly Counter Improvised Explosive Device (IED)) Sciences program provides research for Naval Forces to fight hybrid threats, and adversaries in expeditionary operations. Naval Expeditionary Forces need science advances to address a range of Basic Research challenges that result from physical and operational environmental limitations so harsh that solutions push basic discovery and invention. Naval Forces able to operate amphibiously and in the littoral will have all of their capabilities exposed to degrading sea and land physical effects. Expeditionary forces operating austerely must be agile and lethal but will be constrained by size, weight, and power requirements and must					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
be sustained across distributed forces covering large areas. Further complicating the problem context is the nature of hybrid threats, and adversaries. A hybrid adversary can be state or non-state using a combination of conventional and irregular methods and weapons. For example a hybrid threat could use criminal acts in concert with conventional artillery and IEDs and in turn social media for combined effects greater and broader than the sum of the parts. These coordinated multivariate threats occur across the spectrum of conflict with a dynamic but unified strategy. A hybrid adversary is flexible and adapts quickly, synchronizing advanced state weapons systems, disruptive commercial technologies, cheap expedient homemade weapons, and a variety of tactics. The Sciences Addressing Hybrid Threats program seeks to establish and nurture science to address these threats not covered in more conventional warfare science efforts and in environments not researched elsewhere. Within the above threat and environmental context numerous warfighting capability dependencies are considered resulting in a broad range of science research areas. Examples include: physics addressing the electromagnetic spectrum for use in Command and Control and high energy physics addressing Directed Energy Weapons; machine perception, reasoning and collaborative behaviors of autonomy enabling numerous potential expeditionary autonomous systems; artificial intelligence enabling future Intelligence systems; optics, electronics, and photonics research to enable revolutionary spectral awareness in small low power sensors; computer and network science to enable expeditionary computing coupled with Data Science research to conduct data analysis; fundamental chemistry and materials science research to advance technologies to support sustainment; basic materials research to explore and improve armor and structural materials; electrochemical energy conversion and storage research to sustain the force; chemistry and physics to provide disruptive energetics for expeditionary Fires; and biology, physiology, and cognitive sciences addressing the Naval Expeditionary warfighters human abilities. The program also seeks to establish and nurture a multidisciplinary Science and Technology community of Government, academic and industry researchers to accelerate the transition of new science and technology into fielded systems. Accomplishments and plans described below are examples for each effort category. ***FY 2019 Plans:*** Electronics Create new knowledge and understanding and explore new concepts, techniques and methods, for the design, growth, and characterization of electronic and electro-optic sensors to counter Improvise Explosive Device (IED's).					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Materials and Chemistry Evaluate and quantify the changes in electrical signaling, resulting from strain on the neuronal cells subjected to shock and blast waves. The study is critical to define and understand blast and impact injuries at the cellular level resulting in mild or severe traumatic brain injury. Studies on hearing loss from repeated exposure to high levels of acoustic waves created by high performance jet engines operating on ocean platforms. Understanding of fundamental changes on IR optical standoff and point detection of improvised explosives, chemical warfare agents and toxic industrial chemicals. Develop and demonstrate a predictive framework of IR spectral signatures based on the fundamental optical properties of materials. Earlier studies on related topics have provided design and fabrication of protection garments from IED explosives and advanced design concepts for helmets to significantly reduce neuronal damage caused by shock and blast waves. ***FY 2020 Base Plans:*** Conduct work in hazard defeat to understand new concepts, techniques and methods, for the design, growth, and characterization of electronic, electro-optic, and bio sensors to counter hybrid explosive hazards threats, immersive sciences for automated methods for generating content and/or behaviors for use augmented and mixed reality technologies, and neuromorphic computing and novel opto-electronic technologies. End perovskite chemistry based solar cell efforts. Initiate efforts in understanding multifunction machine learning and artificial intelligence systems operating in realistic electromagnetic threat environments. Evaluate and quantify the changes in electrical signaling, resulting from strain on the neuronal cells subjected to shock and blast waves. The study is critical to define and understand blast and impact injuries at the cellular level resulting in mild or severe traumatic brain injury. Studies on hearing loss from repeated exposure to high levels of acoustic waves created by high performance jet engines operating on ocean platforms. Understanding of fundamental changes on IR optical standoff and point detection of improvised explosives, chemical warfare agents and toxic industrial chemicals. Develop and demonstrate a predictive framework of IR spectral signatures based on the fundamental optical properties of materials. Earlier studies on related topics have provided design and fabrication of protection garments from IED explosives and advanced design concepts for helmets to significantly reduce neuronal damage caused by shock and blast waves. Novel biomaterials that enable epidermal electronics for warfighter protection to light weight distributed chemical sensors. ***FY 2020 OCO Plans:***					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increase from FY 2019 to FY 2020 is a result of the realignment of funds within this Program Element (PE), from Basic Research Challenge Activity into Sciences Addressing Hybrid Threats Activity to better identify and continue automated intelligence for logistics, neuromorphic computing for drone navigation and scene interpretation, and immersive sciences for virtual reality that were initiated as part of the FY 2019 Basic Research Challenge program.					
Title: HUMAN SYSTEMS ***Description:*** Discovery research on attention and decision making in human and human-machine teaming tasks related to Naval missions, including command decision making, cognitive systems for human-machine teaming; computational neuroscience, human interactions with autonomous systems, attention and sensory processing; social cultural and behavioral modeling, and social network and computational social sciences. Accomplishments and plans described below are examples for each effort category. ***FY 2019 Plans:*** Human Computer Interaction/Visualization Conduct basic research in the computer centric environment of today's Navy and Marine Corps. Study human systems integration to reduce workload and increase operator situational awareness in a command information center environment. Investigate human sensory performance for optimizing video and audio human-electronic device interfaces and computational neuroscience for novel pattern recognition and sensory augmentation. Continue research on socially guided machine learning to include robotic teammates learning from human teachers by demonstration and verbal instruction. Conduct research of human-robot interaction to support team collaboration and research to address visualization and synthesis from multiple data sources to support autonomous systems and small hybrid teams. Continue research on brain-inspired intelligent systems to enable high-level interaction between warfighters and autonomous systems. Command Decision Making (CDM) Conduct basic research to explore the development of algorithms to automate assessment of the information value of Command and Control (C2) related data for next generation C2 systems. Research strategies to incorporate uncertainty into mission planning and asset allocation in naval missions and to understand and	15.153	16.486	18.563	0.000	18.563

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
dynamically model context in operational decision making. Explore decision support as it applies to rapid mission planning, re-planning and execution at command and combatant echelons. Research thrust to include dynamic mapping of decision space and decision-based, dynamic task allocation algorithms. Continue research on geography, health and disaster for next generation information systems for collaborative humanitarian assistance. Seek a unified theory of the overall decision process, including the role of judgment with the goal that the unified theory will link currently existing, but isolated, conceptual theories of decision making, judgment, sensing, and detection. Social Network Analysis Research on computational social science models for course of action and forecast in support of information environment maneuvers for strategic communication. Hybrid Human Computer Systems Conduct basic research into creating systems in which the functions of a human operator (or a group of operators) and a machine are integrated. Perform research to explore concepts of operations for the management of information in hybrid autonomous systems. Execute research to improve collaborative systems and trust in computer mediated environments. Investigate statistical language translation for content analysis of threat behaviors and human security issues. Conduct research of neuro-control of high-lift bio-inspired Unmanned Underwater Vehicles and active vision and cognitive navigation skills in mobile robots. Continue program on implantable electronics for performance enhancement. Enhancing Warfighter Cognitive Capability Conduct basic research into probabilistic reasoning in computation cognitive architectures and the expansion of the cognitive architectural modeling capability to increase coverage, including spatial reasoning, multitasking, and impact of physiological and stress variables. Extend research into a program to combine cognitive architectures with computational neuroscience to better predict human performance. Research the output human performance usability models with actual human performance results obtained in usability testing on systems under development. These systems include future Naval Combat Systems and Homeland Security Operation Centers. Continue research of human activity and intend recognition and dynamic biometrics for improved human system interfaces and force protection. Conduct research of human cognition and performance to create more realistic simulations for training, including research into cost effectively adapting current intelligent					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
tutoring technologies to wider dissemination across Navy schoolhouses. Extend training scientific study into the development of intelligent, embedded assessment for Intelligent Tutoring System (ITS). Research cognitive modeling for cybersecurity and research on human performance sources of cyber vulnerabilities of unmanned vehicle (UxV) systems. Develop computational models for predicting human error on procedural tasks. Investigate training efforts on neuro-cognitive plasticity.					
FY 2020 Base Plans: Command Decision Making Develop approaches for proactive decision support for Naval command and control tasks, with an emphasis on supervised machine learning of expert planning and dynamic re-planning. Human-Machine Teaming Develop empirical and computational models of cognition and create algorithms and architectures that aspire to human-level intelligence or ability. The algorithms and cognitive models serve to: (i) Advance the understanding of human cognition; (ii) Enable systems to recognize, understand, predict, perform, assist, and evaluate human behavior; and (iii) Improve the effectiveness of intelligent systems, human users/operators, and hybrid human-machine teams in Naval operations. Neurosciences and Human Interaction With Autonomous Systems Develop neuroscience principles to identify neural circuits, architectures, and algorithms that can be emulated to develop novel sensing, control, pattern recognition, neuromorphic processors, and intelligent systems. Conduct research on neural mechanisms of memory consolidation, working memory, and retrieval to enable intelligent systems with human-like associative memory skills. Attention In Sensory Processing Develop mechanisms of attention, including its role in skilled perceptual and cognitive performance. Understand attention to task-relevance as a factor in personnel selection and training. Incorporate mechanisms of attention into machine learning. Social, Cultural, and Behavioral Modeling					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Develop computationally-efficient methods to model human behavior and social network analytics. Efforts include modeling information and cyber warfare, as well future sensor and weapon developments and their impact on Warfighter performance. Use machine learning to create synthetic decision makers. Social Networks and Computational Social Science Develop methods and tools pertaining to social media network analysis, including problems of monitoring social media, social hysteria propagation, and group polarization to support methods for information environment assessment, humanitarian assistance, and disaster response. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increase from FY 2019 to FY 2020 is a result of the realignment of funds within this Program Element (PE), into the Human Systems Activity, to better identify and continue emerging sciences, including warfighter performance, command decision making, cognitive systems for human-machine teaming, computational neuroscience, human interactions with autonomous systems, attention and sensory processing, social cultural and behavioral modeling, and social network and computational social sciences efforts that were initiated as part of the FY 2019 Basic Research Challenge program.					
Title: MATHEMATICS, COMPUTER, & INFORMATION SCIENCES	44.376	45.870	62.032	0.000	62.032
Description: Efforts include: Mathematical foundation and computational theory and tools for design, communication, and control of intelligent autonomous systems; theory, algorithms and tools for decision support; decision theory, algorithms, and tools; heterogeneous information integration, management, and presentation; information assurance, computation and information foundation for cyber defense, secure and reliable information infrastructure for command and control; mathematical optimization for optimal resource allocation and usage; modeling and computation of complex physical phenomena; modeling and computation for electromagnetic and acoustic wave propagation and scattering; seamless, robust connectivity and networking; foundations for novel computing hardware, including nanoscale materials, emerging devices and circuits, emerging computational architecture and nanofabrication. Accomplishments and plans described below are examples for each effort category.					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
FY 2019 Plans: Communications and Networking Conduct basic research in antenna technology to include electrically small antennas, wideband multifunction antennas, compatibility of phased array antennas with naval platforms and marine environments, directional beam forming/steering techniques, and special-purpose submarine communication antenna systems; radio communications to include anti-jam and low-probability-of-intercept techniques, SATCOM performance enhancements, interference mitigation, adaptive equalization, bandwidth efficient modulation, cognitive radio for dynamic spectrum management, and high data rate tactical communications techniques including communications at speed and depth (for submarines); and wireless networks to include mobile ad-hoc wireless networking algorithms/protocols, end-to-end Quality-of-Service, joint/coalition interoperability, service oriented tactical networking, mission-based policy and network controls and management. Quantum Information Sciences Continue basic research of quantum key distribution (QKD) protocols and implementations for the purpose of understanding the security implications for QKD in the maritime environment, the development of protocols that simultaneously minimize leakage of information to the environment and the creation of secure networks, as well as schemes to maximize the information carried by a continuous or discrete variable; and research of algorithms for naval functions such as routing, weapon-target pairing, etc., a key application such as radar cross section calculation. Nanoscale Computing Devices and Systems Develop novel techniques for synthesis, assembly and characterization of molecular scale (sub-10nm) Nano graphene structures for their electronic, optical, magnetic and quantum functionalities. Research, assess, test and develop alternative computing architectures (beyond von-Neumann), including but not limited to, various implementations of neuromorphic architectures and quantum information systems. Mathematical Data Science Conduct basic research in mathematics, probability, statistics, signal processing, machine learning, data engineering, and information theory. The program aims to develop rigorous mathematical and algorithmic					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
answers to questions that are currently addressed using heuristics or non-principled approaches. Focus is on problems in learning and inference from both big and small data, representation of data, modeling dynamical properties of and determining causal effects in complex networks, multi-modal, multi-scale information integration, and decision making under uncertainty. Machine Learning, Reasoning and Intelligence Conduct basic research in the area of building intelligent agents that can function in the environments in which warfighters operate, that is, environments that are unstructured, open, complex and dynamically changing. Agents (cyber or physical) do not yet have the level of intelligence needed to operate in such open, uncertain and unpredictable environments either independently or alongside warfighters. In the area of Intelligence for Autonomous Agents, basic research includes the development of principles for machine intelligence, efficient computational methods, algorithms and tools for building versatile smart agents that can perform missions autonomously with minimal human supervision and collaborate seamlessly with teams of warfighters and other agents. In the area of Image Understanding, basic research includes the development of theory and algorithms for understanding surveillance imagery, for semantic search of visual datasets, and for autonomous agent perception. The main focus is on reconstructing 3D scenes, recognizing object classes and specific objects, recognizing activities and events, inferring intentions, as well as succinct natural language descriptions of images and video. Applied and Computational Analysis Program Conduct basic research in modern and classical mathematical analysis with emphasis on mathematical and computational models of physical phenomena. Naval interest in waves, flows, materials, structures, and information processing motivates research in the areas of multi-phase, multi-physics, including analytically rigorous and computationally robust and efficient modeling of fatigue, fracture, dislocation, nucleation, shocks and contact lines; dynamical systems, and oceanic and atmospheric modeling, including fluid transport, mixing, and predictability of models for nonlinear dynamics; and inverse problems arising from acoustic and electromagnetic wave propagation and scattering. Cyber Security and Complex Software Systems Conduct basic research in computing systems and complex software systems that meet required assurances for security, safety, reliability and performance to measurably improve the information-processing challenges					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
of future naval systems. Cyber Security sub-program investigates and develops wide-ranging principles and techniques for continuously maintaining confidentiality, integrity, and availability of information and information infrastructures, focusing on the software, the hardware and the network. The program seeks to establish an autonomic, secure and dependable informational infrastructure toward achieving Information Dominance. Complex Software sub-program investigates principles, algorithms and methods, and develops software engineering tools for achieving efficient, timely, robust and secure software executables, focusing on science for software construction, correctness and efficiency by revisiting software development and deployment methodology. Efficient, timely, robust and secure software is a requirement for secure information infrastructure toward achieving Information Dominance. Networked Sensing Conduct basic research in optical components and infrared technologies including lasers and focal plane arrays using narrow bandgap semiconductors for the purpose of imaging through clouds, fog, haze and dust; persistent surveillance for severely size constrained airborne applications; detecting anomalies and targets; and autonomous sensing for UAV platforms and networked sensing over multiple sensors and/or sensor platforms. Mathematical Optimization and Operations Research Conduct basic research in mathematical optimization. The primary focus of the program's basic-research portion is linear, nonlinear, integer and combinatorial optimization. Theoretical development, algorithm design and analysis, computational techniques, and software prototypes for solving large-scale problems are of interest. Techniques that produce provably optimal or near-optimal solutions, as well as techniques applicable to large problem domains are favored. This includes, but is not limited to, cutting-plane and polyhedral techniques for mixed-integer programming and interior-point and first- order algorithms for conic/convex optimization. Decentralized optimization is an area of growing interest, as are innovative techniques for dealing with uncertainty, such as stochastic, robust, and online optimization. Information Technology To address the continued need for improving the operational capability of Naval information and communication systems in the areas of: high assurance software; secure tactical connectivity; intelligent autonomy; and the processing, integration, and presentation of information. The expected payoff is: the development of improved methods for producing, analyzing, and securing Naval software systems; new design concepts for future					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Naval tactical communication systems and networks; intelligent autonomy and improved interaction with autonomous systems; and improved methods for analyzing, integrating, and presenting information to users. Specific research examples include security for systems that employ Systems-on-a Chip Integrated Processor architectures, AI systems that understand causal reasoning, robotic systems that take advantage of emerging neuromorphic processors, new algorithms for performing data analytics, and networks that take into account the age of the information on the network for routing decisions.					
FY 2020 Base Plans: Communications and Networking Conduct basic research in antenna technology to include electrically small antennas, wideband multifunction antennas, compatibility of phased array antennas with naval platforms and marine environments, directional beam forming/steering techniques, and special-purpose submarine communication antenna systems; radio communications to include anti-jam and low-probability-of-intercept techniques, satellite communications (SATCOM) performance enhancements, interference mitigation, adaptive equalization, bandwidth efficient modulation, cognitive radio for dynamic spectrum management, and high data rate tactical communications techniques including communications at speed and depth (for submarines); and wireless networks to include mobile ad-hoc wireless networking algorithms/protocols, end-to-end Quality-of-Service, joint/ coalition interoperability, service oriented tactical networking, mission-based policy and network controls and management. Quantum Information Sciences Conduct basic research of quantum key distribution (QKD) protocols and implementations for the purpose of understanding the security implications for QKD in the maritime environment, the development of protocols that simultaneously minimize leakage of information to the environment and the creation of secure networks, as well as schemes to maximize the information carried by a continuous or discrete variable; and research of algorithms for naval functions such as routing, weapon-target pairing, etc., a key application such as radar cross section calculation. Nanoscale Computing Devices and Systems Develop novel techniques for synthesis, assembly and characterization of molecular scale (sub-10 nanometers) nanographene structures for their electronic, optical, magnetic and quantum functionalities. Research, assess,					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
test and develop alternative computing architectures (beyond von-Neumann), including but not limited to, various implementations of neuromorphic architectures and quantum information systems. Mathematical Data Science Conduct basic research in mathematics, probability, statistics, signal processing, machine learning, data engineering, and information theory. The program aims to develop rigorous mathematical and algorithmic answers to questions that are currently addressed using heuristics or non-principled approaches. Focus is on problems in learning and inference from both big and small data, representation of data, modeling dynamical properties of and determining causal effects in complex networks, multi-modal, multi-scale information integration, and decision making under uncertainty. Machine Learning, Reasoning and Intelligence Conduct basic research in the area of building intelligent agents that can function in the environments in which warfighters operate, that is, environments that are unstructured, open, complex and dynamically changing. Agents (cyber or physical) do not yet have the level of intelligence needed to operate in such open, uncertain and unpredictable environments either independently or alongside warfighters. In the area of Intelligence for Autonomous Agents, basic research includes the development of principles for machine intelligence, efficient computational methods, algorithms and tools for building versatile smart agents that can perform missions autonomously with minimal human supervision and collaborate seamlessly with teams of warfighters and other agents. In the area of Image Understanding, basic research includes the development of theory and algorithms for understanding surveillance imagery, for semantic search of visual datasets, and for autonomous agent perception. The main focus is on reconstructing 3D scenes, recognizing object classes and specific objects, recognizing activities and events, inferring intentions, as well as succinct natural language descriptions of images and video. Applied and Computational Analysis Program Conduct basic research in modern and classical mathematical analysis with emphasis on mathematical and computational models of physical phenomena. Naval interest in waves, flows, materials, structures, and information processing motivates research in the areas of multi-phase, multi-physics, including analytically rigorous and computationally robust and efficient modeling of fatigue, fracture, dislocation, nucleation, shocks and contact lines; dynamical systems, and oceanic and atmospheric modeling, including fluid transport,					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
mixing, and predictability of models for nonlinear dynamics; and inverse problems arising from acoustic and electromagnetic wave propagation and scattering. Cyber Security and Complex Software Systems Conduct basic research in computing systems and complex software systems that meet required assurances for security, safety, reliability and performance to measurably improve the information-processing challenges of future naval systems. Cyber Security sub-program investigates and develops wide-ranging principles and techniques for continuously maintaining confidentiality, integrity, and availability of information and information infrastructures, focusing on the software, the hardware and the network. The program seeks to establish an autonomic, secure and dependable informational infrastructure toward achieving Information Dominance. Complex Software sub-program investigates principles, algorithms and methods, and develops software engineering tools for achieving efficient, timely, robust and secure software executables, focusing on science for software construction, correctness and efficiency by revisiting software development and deployment methodology. Efficient, timely, robust and secure software is a requirement for secure information infrastructure toward achieving Information Dominance. Networked Sensing Conduct basic research in optical components and infrared technologies including lasers and focal plane arrays using narrow bandgap semiconductors for the purpose of imaging through clouds, fog, haze and dust; persistent surveillance for severely size constrained airborne applications; detecting anomalies and targets; and autonomous sensing for Unmanned Autonomous Vehicle (UAV) platforms and networked sensing over multiple sensors and/or sensor platforms. Mathematical Optimization and Operations Research The primary focus of the Mathematical Optimization program is the development of new, cutting-edge theory and algorithms for most efficiently solving problems in linear, nonlinear, integer, and combinatorial optimization. Theoretical development, algorithmic design and analysis, computational methods, and software prototypes for large-scale problems are of interest. This directive includes, but is not limited to, cutting plane and polyhedral techniques for mixed-integer programming, decomposition approaches for large (non)convex problems, and interior-point and first-order algorithms for conic/convex optimization. Advances that produce provably optimal or near-optimal solutions, as well as those applicable to large problem domains are favored.					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Innovative strategies for dealing with uncertainty from stochastic optimization, robust optimization, and simulation-based optimization are of growing interest. Research supported by this program is expected to make fundamental contributions to the areas of mathematical optimization and operations research. Information Technology: To address the continued need for improving the operational capability of Naval information and communication systems in the areas of: high assurance software; secure tactical connectivity; AI and autonomy; and the processing, integration, and presentation of information. The expected payoff is: the development of improved methods for producing, analyzing, and securing Naval software systems; new design concepts for future Naval tactical communication systems and networks; intelligent autonomy and improved interaction with autonomous systems; and improved methods for information analysis, fusion, and presentation. New research projects will deliver technology for improved AI inference and human/AI interaction, predictive models for human cognitive performance, models for predicting and controlling complex networks in uncertain and hostile environments, and technology for improved presentation of complex, information-rich datasets. Integration of domain knowledge and machine learning to enable fast and robust learning of diverse, complex concepts and tasks. Development of artificial intelligence in support of: (i) Informing and assisting different stages of the decision making process, and (ii) Developing interfaces and dialogue systems for human-machine teaming. Efforts in distributed artificial intelligence will identify principles and tractable computational methods for flexible and resilient approaches to learning, sharing, reasoning, and decentralized planning for situation awareness. Efforts will develop brain-inspired artificial intelligence algorithms and architectures and neuromorphic hardware to accelerate deep learning. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increase from FY 2019 to FY 2020 is a result of the realignment of funds within this PE, from Basic Research Challenge Activity and Science of Artificial Intelligence Activity into Mathematics, Computer & Information Sciences Activity. Better identify and continue Quantum Information Sciences, Mathematical Data Science, and Applied and Computational Analysis Program efforts initiated as part of the FY 2019 Basic Research Challenge program. This funding increase is also responsive to Navy guidance to the Navy Science					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
and Technology (S&T) community to provide substantial leadership and stewardship to the overall development of artificial intelligence and its military applications.					
Title: MATERIALS/PROCESSES	55.706	58.270	58.636	0.000	58.636
Description: Efforts include: structural materials; functional materials; maintenance reduction; environmental sciences; undersea warfare, materials and chemistry, and manufacturing science. Accomplishments and plans described below are examples for each effort category. This activity also includes peer-review basic research to develop innovative solutions and enhance the science and engineering base. Accomplishments and plans described below are examples for each effort category. Beginning in FY 2020, The Environmental Science thrust has been relabeled Functional Materials to address the evolution of work within this program area. ***FY 2019 Plans:*** Structural Materials Conduct basic research related to critical S&T for structural materials, including, but not limited to, the following: computer-aided materials design (CAMD), structural metals, polymer composite materials, solid mechanics, propulsion materials, sensors & NDE prognostics and structural cellular materials. Functional Materials Conduct basic research related to critical S&T for functional materials, including, but not limited to, the following: electronic materials, transduction materials, nanoparticles, bacterial nanowires and oxide materials. Expand research related to acoustic transduction science. Maintenance Reduction Conduct basic research related to critical S&T for maintenance reduction, including, but not limited to, the following: corrosion models, stainless steel carburization, corrosion, and coatings. Environmental Science					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Conduct basic research related to critical S&T for environmental science, including, but not limited to, the following: examination of scientific methods for pollution prevention, waste reduction, and hazardous material reduction for Naval Operations, anti-fouling and fouling release coatings including investigation of effect of new polymers, materials, processes, and novel testing methodologies for coating efficacy, and Reverse Osmosis (RO) pre-treatment strategies. Expand research related to naval environmental science. Manufacturing Science Conduct basic research related to critical S&T for manufacturing science, including, but not limited to, the following: multidisciplinary research task into furthering the sciences associated with advances in manufacturing processes. Undersea Warfare Perform laboratory and theoretical/numerical studies focused on creating new techniques for detecting, visualizing, understanding, predicting, exploiting, and controlling the interactions between acoustic and elastic waves such as: underwater coupling architectures that achieve a broad range of acoustic impedances, refractive indices and loss tangents; and the creation of high efficiency silicon based thin film thermoelectric modules for undersea warfare applications by exploiting nanocrystallization, multilayering to control thermal conductivity. Materials and Chemistry Designing advanced materials depends on novel synthesis, processing, characterization, and performance. This effort addresses all materials including metals, alloys, ceramics, composites, semiconducting and superconducting material and bimolecular materials. Some examples of ongoing studies are (1) uncovering the mechanisms in the nanometer scale, (2) understanding the effect of coatings on the conductions of ions and electrons, (3) developing better understanding on the performance of spin-polarized electrons for advanced electronic switches and memories, (4) developing fundamental understanding of electron transfer pathways in microbial consortia and relate the indefinite power generation in benthic regions, (5) understanding the mechanism of the order of magnitude in advance composites consisting of soft polymers and nanoparticles with					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
an effort to design advanced light weight armor. Demonstrate materials using 3D printing, mobility of electrons of one spin, design of microbial cells to extract power from the coastal ocean sediments.					
FY 2020 Base Plans: Structural Materials Conduct basic research related to critical science and technology (S&T) for structural materials, including, but not limited to, the following: structural metals, polymer composite materials, solid mechanics, propulsion materials, sensors & non-destructive evaluation (NDE) prognostics and structural cellular materials. Functional Materials (Formerly Environmental Science) Conduct basic research related to critical S&T for functional materials, including, but not limited to, the following: transduction materials, acoustic transduction science, nanoparticles, oxide materials, and anti-fouling and fouling release coatings including investigation of effect of new polymers, materials, processes, and novel testing methodologies for coating efficacy for environmental quality control. Maintenance Reduction Conduct basic research related to critical S&T for maintenance reduction, including, but not limited to, the following: corrosion models, stainless steel carburization, corrosion, and coatings. Manufacturing Science Additive Manufacturing (AM) using structural metals is of particular interest to the Navy for a wide variety of applications. However, the composition and properties of the AM alloy can change significantly during deposition, requiring new alloy development efforts to determine the initial composition that will produce the intended composition and properties in the AM-fabricated component. This effort will begin to address the need by designing, developing and optimizing new metallic alloy compositions for AM that are resistant to the effects of the Naval/maritime environment. Materials and Chemistry					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Designing advanced materials depends on novel synthesis, processing, characterization, and performance. This effort addresses all materials including metals, alloys, ceramics, composites, semiconducting and superconducting material and bimolecular materials. Some examples of ongoing studies are (1) uncovering the physical, chemical, optical and biological phenomena in the nanometer scale, (2) understanding the effect of coatings on the conductions of ions and electrons, (3) developing better understanding on the performance of spin-polarized electrons for advanced electronic switches and memories, (4) developing fundamental understanding of electron transfer and carbon fixation pathways in microbial consortia and relate them to energy harvesting, material synthesis ans sensing, (5) understanding the mechanism of bioactuation for novel would healing applications, biocatalysis for mitigation and sensing, biocorrosion/fouling for improving operational efficiency and reducing operational maintanace cost, (6) computational capabilities to understand the microstructures/defects in metals and alloys of Naval interest, computational fluid dymnamics simulations for jet engine noise reduction, flapping wing design to hypersonics. Several accomplishments have been demonstrated for materials using 3D printing, mobility of electrons of one spin, design of microbial cells to extract power from the coastal ocean sediments. Undersea Warfare Laboratory and theoretical/numerical studies focused on creating new techniques for understanding, predicting, and controlling the interactions between acoustic and elastic waves such as: underwater coupling architectures that achieve a broad range of acoustic impedances; and the creation of high efficiency silicon based thin film thermoelectric modules for undersea warfare applications by exploiting nanocrystallization, multilayering to control thermal conductivity. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY2019 to FY2020.					
Title: MEDICAL/BIOLOGY	18.624	19.601	19.707	0.000	19.707
Description: Discovery research on bio-inspired autonomous systems; biorobotics; bioengineering; synthetic biology; microbial electrochemical systems and microbiome research; augmented Warfighter performance; sensory neuroscience; stress physiology; Naval force health protection; undersea medicine and performance; and health and welfare of the Navy's marine mammals. To avoid duplication of efforts, research is coordinated					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
with other Services through interactions with the Defense Health Agency, Armed Services Biomedical Research Evaluation and Management (ASBREM) Community of Interest, and Human Systems Community of Interest. ***FY 2019 Plans:*** Medical Sciences: Undersea Medicine Conduct basic research into stress physiology, hyperbaric physiology, and biological effects of Naval operational exposure. Explore the mechanisms of decompression illness, hyperbaric oxygen toxicity and "ultrasonic" hearing in divers. Determine ways to mitigate underwater sound/blast effects. Improve trauma management in submarine Special Forces operators. Research the physiological and genetic effects of long-term diving including in extreme environments (hypoxic and/or hypobaric conditions). Assess the effects of hyperbaric oxygen therapy on blast-induced histopathological changes. Continue research into the effects of hyperbaric environments on cellular biology (metabolism and signaling). Biomedical Sciences and Environmental Physiology Conduct basic research to explore systematic relationships between cognitive and physiological responses under operational conditions. Research the effects of psychological and physiological stress, sleep deprivation and fatigue on the immune system and human performance. Investigate novel mechanisms to manage the mammalian circadian system for optimized health and performance. Research the mechanisms of nitrogen narcosis/high pressure nervous syndrome. Explore novel opioids with minimal side effects. Study bioderived systems to produce fieldable therapeutics. Develop strategies for nerve cell regeneration. Research regenerative medicine in concert with the Armed Forces Institute for Regenerative Medicine (AFIRM). Combat and Operations BioMedicine Conduct basic research in casualty care and management and casualty prevention, including mechanisms investigations of hemorrhagic shock, blast injury, tissue repair, and the biomedical effects of military operational exposure such as directed energy, hazardous chemicals, and sound. Explore health and individual performance under various military environments such as heat, cold, enclosed space, pressure and acceleration. Investigate the mechanisms of blast-induced neurotrauma at the cellular level, including underwater blasts. Initiate					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
investigations of multi-scalar mechanisms of military occupational hazard and injury generation, detection, and repair, such as cavitation and directed energy. Biological Sciences: Naval Biosciences Investigate microbe-materials interfacial interactions for detection of materials defects/failures, including corrosion, and for improved energy harvesting. Investigate "smart cell engineering" to design microbes that can sense and destroy other microbes and provide feedback to the user. Continue research on invertebrate larval response to biofilms and various inhibitors of adhesion. Identify molecular biomarkers for battlefield injuries, and high-fidelity biosensors for detection in vivo. Study biomolecular 'logic controllers' for in vivo biosensor and drug delivery systems. Research into synthetic biology to further efforts for designing organisms with non-natural functions (e.g., light detection, electrical 'switch' capability, magnetic field production). Identify natural product inhibitors of bacterial folate biosynthesis for development as antibiotics. Control the synthesis of patterned materials from the nano to micro-scale using bionanotechnology. Understand the role of human gut microbiome to behavioral and physical stressors. Integrate programmable, externally-controlled "sensor" cells into micro-robotic devices. Study synthetic biology bioelectronics and information processing. Initiate synthetic biology of gut microbes for warfighter resilience. Life Sciences and Bioengineering Conduct basic research into combinatorial chemical screens for bacterial communication pathway inhibitors as potential antibiotics or fouling control agents. Identify plasma biomarkers of domoic acid toxicosis and leptospirosis in California sea lions, and develop a multiplexed assay to measure those plasma biomarkers. Research the potential clinical role of marine mammal stem cells. Investigate DNA-scaffold-directed assembly of protein nanoarrays for control over orientation and position of proteins, and investigate triggered isothermal assembly of DNA nanostructures. Compare commensal/pathogenic microbiomes in Atlantic bottlenose dolphin, California sea lion, and in dolphin diagnosed with chronic/active gastritis. Develop new tools and techniques to engineer and characterize DNA nanostructures and control DNA based nanodevices. Investigate the material properties of silk proteins to facilitate application development. Develop field portable sensing platforms for explosives detection. Study environmental effects on marine invertebrate biofouling. Neural, Sensory and Biomechanical Systems					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Conduct basic research into the development of bio-inspired sensors, vehicles and systems for local Intelligence, Surveillance and Reconnaissance (ISR), Weapons of Mass Destruction (WMD) detection, personnel protection and affordability including microfabrication, biological materials, processing techniques, robustness and systems efficiency. Research the elucidation of mechanisms of fish electric sense and near field low frequency acoustic perception. Investigate bacterial/cellular controllers for nano/micro-systems. Combat and Operations BioMedicine Research improved hemorrhage resuscitation with enhanced endothelial treatments. Naval Biosciences Research synthetic biology for bioelectronics devices, materials and information processing.					
FY 2020 Base Plans: Bio-Inspired Autonomous Systems Develop bio-inspired propulsion and control systems that enable high-lift, stealthy propulsion without propellers and achieve high maneuverability for underwater vehicles. Efforts include: (i) Bio-sensing for sensorimotor control; (ii) Bio-inspired design principles for distributed sensing, actuation and control in soft biological structures; and (iii) Principles of locomotion of amphibious animals to enable bio-inspired amphibious and cross-domain vehicles. Bioengineering and Life Sciences Develop DNA-based nanostructures for fundamental circuits and biosensing; biomimetic and bio-inspired underwater adhesives; biopolymer energy sources; and explore approaches to generate nanomaterials by design. Pursue research in biological and bio-inspired, water-responsive materials for energy conversion and actuators. Maintain the health and fitness of the U.S. Navy's marine mammals for duty and readiness. Naval Biosciences and Synthetic Biology for Naval Applications					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Develop research on synthetic biology for bioelectronics devices, materials, and information processing. Efforts include: (i) Elucidating microbe-materials interactions and extracellular electron transfer mechanisms for detection of materials defects/failures, identifying novel biogenic structures, and improving microbial electrochemical functions; (ii) Exploring the role of the human microbiome in host response to behavioral and physical stressors; (iii) Developing synthetic biology approaches to enable manipulation of microbiome organisms for Warfighter resilience or status monitoring; (iv) Executing research on synthetic biology approaches to enable novel bioelectronics and information processing strategies. Warfighter Augmentation Develop cognitive and physiological systems that enable human performance to exceed current limitations, including novel adaptations to inhospitable environments. Efforts include: Alternative oxygen sources, epigenetic modifications of globin protein expression for variable regulation of oxygen tissue supplies, bionics, texture-shifting of biological organisms, and multi-functional textiles. Sensory Neuroscience and Physiology Investigate neurological pathways of sensory systems including: (i) Examining mechanisms of nerve cell and axonal fiber deterioration in high noise environments; (ii) Accelerating understanding of nerve cell and axonal regeneration; and (iii) Exploring novel treatment strategies for hearing restoration. Physiological Monitoring and Modeling Develop fundamental mechanisms that enable prediction and identification of cognitive and physical performance levels in extreme expeditionary environments. Design novel low-powered sensing capabilities. Naval Force Health Protection Discover technologies including: (i) Novel modeling and simulation approaches to improve Warfighter protection; (ii) Maritime casualty care; and (iii) Medical logistics through optimized design, development, and operational planning. Undersea Medicine and Performance					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Develop cognitive and physiological responses in undersea environments to expand the operational envelope (e.g. depth and time) for divers and combat swimmers. Explore enhancement of human physiology with pharmacological agents and other therapies to protect humans from undersea environmental challenges. Stress Responses Develop impact of military operational environments on biomarkers predictive of individual Warfighter's reactivity to stress. Explore effects of chronic stress in conjunction with circadian cycle changes on these biomarkers. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020					
Title: OCEAN SCIENCES	73.497	76.135	81.641	0.000	81.641
Description: Efforts include: The Ocean Sciences sub activity supports basic research in the ocean domain and the impact that this complex and changing environment has on naval operations. The effort encompasses research over a wide variety of regions, including the open ocean, Arctic, and littorals, and addresses scientific issues relevant to Anti-Submarine Warfare (ASW) including acoustic propagation and the impact of acoustics on marine mammal behavior. The improved understanding of the ocean environment enables the development of fully coupled (ocean-atmosphere-wave-ice) global, regional and local predictive models that can be used for operational planning at tactical, strategic and climate scales. The program is strongly aligned with the Oceanographer of the Navy and the research topics addressed by this sub activity reflects the priorities for improved forecasts of the operational environment and the development and use of autonomous systems for the collection of environmental observations and continuing support to research vessels of the U.S. Academic Research Fleet for operations and maintenance that enable science at sea. Research performed under this Sub Activity includes efforts in the following areas: littoral geosciences and optics, marine mammals and biology, physical oceanography and prediction, and ocean acoustics. Accomplishments and plans described below are representative highlights from these efforts. This Program requires field research that involves participation in Navy environmental planning efforts including environmental planning documents (Environmental Impact Statements). The use of active acoustic transmissions requires modeling of the acoustic effects of sound on marine life. ***FY 2019 Plans:***					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Physical Oceanography and Prediction Carry out field experiments to investigate changes in Arctic stratification and circulation and related physical processes in the Beaufort and Chukchi Seas. Carry out a multidisciplinary field effort to characterize and understand monsoon intra-seasonal variability in the Indian Ocean. Complete field studies/modeling to predict propagation and effect on acoustics of non-linear internal waves in the western Pacific. Complete studies of internal waves and strait dynamics emphasizing field studies in the Celebes, Philippine, and Sulu Seas. Complete analysis of the structure and variability of the Northern Arabian Sea circulation using autonomous, unmanned sampling systems. Initiate studies of prediction and observations of 3-D Lagrangian studies and abilities to predict the vertical pathways in the ocean. Initiate studies of the input and fate of near-initial shear and energy in the ocean via observational and predictive studies in the GIUK regions. Littoral Geosciences and Optics Initiate studies and modeling of shelf, near-shore, delta, estuarine, and riverine dynamics, including surface and internal waves, currents, stratification, sediment transport and the seabed response and coastal winds driving shallow water response. Understanding shallow water features which will affect acoustic propagation or acoustic system performance and/or events which cause swimmer or navigational hazards (bathymetry-wave-current-wind interactions), navigationally significant bathymetry or trafficability changes, are of particular interest. Initiate studies using remote sensing of the coastal and riverine environment, above and below the sea surface and canopy, e.g., from EO, IR, radar, SAR, inSAR and acoustic, from land or ship-based, unmanned vehicles, airplanes or satellites. New remote sensing tools and algorithms that can be used to initialize forecast models in distant, remote and/or denied areas are of particular interest. Initiate studies of optical processes in the littoral environment, including the atmosphere, sea surface, water column, sea bed and suspended or dissolved materials. Predicting the timing (initiation, transport and clearance) of materials that negatively affect optical clarity, is of particular interest. Studies emphasize methodologies and/or observing technologies which are cost-effective, rapidly re-locatable, and offer insight into littoral phenomena. Studies to enable use of organic sensors on operational platforms to enhance battlespace situational awareness in continental shelf, nearshore, delta, estuarine, and riverine environments, including such phenomena as surface gravity waves and internal waves, currents, stratification, sediment transport and coastal winds. Understanding very shallow water acoustic propagation in coastal, nearshore, deltaic and riverine environments. Marine Mammals and Biology					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Integrated Ecosystem Research Basic research to understand the patterns and causes of variability in the distribution and abundance of marine mammals over space and time. Research a multidisciplinary approach using tagging, visual surveys, and passive acoustics to collect baseline measures of marine mammal behaviors and distributions relative to environmental features and marine mammal prey fields. Investigate using animal tagging and passive acoustic monitoring to study behaviors and distributions of marine mammals relative to key environmental properties (biotic and abiotic). This includes providing a context for interpreting behavioral responses to external stimuli (i.e. anthropogenic sound), and providing basic knowledge needed for predictive models of species of concern. Effects of Sound Basic research on behavioral, physiological (hearing and stress response), and potentially population-level consequences of sound exposure on marine life. Research to characterize the causal chain of events leading from sound exposure to "biologically significant" behavioral reactions that might increase risks of population-level effects and/or the potential for stranding. An additional focus is to characterize the gas management and kinetics (stores and use) in marine mammals. Research the mechanisms that enable marine mammals to dive to deep depths for long durations while mitigating, if not avoiding, health threats. Initiate research to advance our understanding of sound reception mechanisms in mysticetes (large whales) will require a thorough exploration of the anatomy surrounding the ear and the whole head combined with modeling sound propagation through various tissues of whale heads and/or bodies. Another research focus is to better understand the stress response in marine mammals to sound exposure. Research an understanding of the natural variation of stress markers, better understand and characterize the relationships among hormones or other biomarkers in different matrices, define and compare the quantitative and temporal relationships of hormones across the different matrices, and evaluate and characterize the relationship between the physiological stress response in marine mammals and acoustic exposure and 'biologically significant' disturbance. Research to develop statistical models of the population consequences of acoustic disturbance to be fitted to data from marine mammal populations and lead collaborative development of transferable models of the effects of disturbance on marine mammals. Monitoring and Detection Basic research to develop and test new and existing technology to detect and classify marine mammals in the marine environment and during periods of low light such as passive acoustics, and IR. Research and					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
development of passive acoustic signal processing algorithms for detection, classification, and localization of marine mammals. Continue the development and testing of autonomous hardware platforms using passive acoustics and/or IR to detect and classify marine mammals using a variety of fixed, towed, floating, and profiling platforms. Ocean Acoustics Research to understand propagation and scattering of acoustic energy in shallow-water ocean environments. Areas of research include: shallow-water scattering mechanisms related to reverberation and clutter; seabed acoustic measurements supporting geoacoustic inversion; acoustic propagation through internal waves and coastal ocean processes and the development of unified ocean/seabed/acoustic models, including scattering from rough surfaces, biologics and bubbles; and penetration/propagation within the porous seafloor. Battlespace Environments Emphasis is on improved measurements, laboratory and model based experiments to quantify and understand important oceanographic processes that lead to the development of ocean dynamic models from global to submesoscale scales, and to couple these oceanographic models with atmospheric, ice, biological, sediment response, and optical models. Surveillance of coastal land areas and waters is important to support Navy operations and difficult. The Navy/Marine Corps needs include an improved use of overhead (airborne and satellite) active and passive microwave sensors, overhead optical sensors, surface-based (ships and ground-based) grazing angle microwave sensors. To predict bottom boundary physical, geological, geochemical, geoacoustic and geotechnical properties in shallow-water operating areas requires: a) an improved understanding of processes that generate and modify the shape, structure and physical properties of the seafloor, subseafloor, ocean water column and ice-cover and topography/morphology; b) use of rapid, airborne characterization of littoral environments including time-varying coastal topography, littoral bathymetry, sea-level height, land and seafloor sedimentary structures to explain/predict the observed changes; c) remote sensing of bulk properties of Arctic sea-ice over broad two-dimensional areas that previously could be sampled only at spot locations by in-situ sampling; and d) quantification of the influence of turbulence generated at the seafloor boundary layer on vertical mixing and stratification in shallow water outside the surf zone. ***FY 2020 Base Plans:*** Physical Oceanography and Prediction					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Complete studies of the flow encountering abrupt topography in the Western Pacific on the mean and transient circulation structures. Continue the study of multi-scale embedded modeling and prediction. Conduct the studies of the prediction of and observations of 3-D Lagrangian studies and abilities to predict the vertical pathways in the ocean. Conduct the evaluation of novel employment of instrumentation including drifters and unmanned undersea vehicles to study these 3-D Lagrangian structures. Conduct the studies of the input and fate of near-initial shear and energy in the ocean via observational and predictive studies in the Greenland, Ireland, United Kingdom (GIUK) regions. Conduct the evaluation and testing and "hardening" of ocean instrumentation in high wave states and austere conditions. Conduct the study of the improvement of prediction systems by identifying, targeting, and obtaining key observations in critical targeted areas. Continue the evaluation of novel delivery systems of expeditionary ocean instrumentation to support targeted observing. Littoral Geosciences and Optics Develop methodologies and/or observing technologies, for air, sea surface or subsurface, manned or unmanned, which are: a) nimble, cost-effective, rapidly re-locatable, or will offer bold insight into littoral dynamics, (e.g., tagging of marine seabirds in the Distributed, Autonomous, Scalable Hydrographic Charting and Meteorology and Oceanography (METOC) Sampling (DASHCAMS) Department Research Initiative (DRI)), or b) utilize sensors on operational platforms in ways which increase battlespace awareness or can be used to map the maritime domain while idle. Conduct studies and modeling of shelf, near-shore, delta, estuarine, and riverine dynamics, including surface and internal waves, currents, stratification, sediment transport and the seabed response (Inner Shelf DRI) and coastal winds driving shallow water response (Coastal Land-Air-Sea DRI). Conduct studies to understand shallow water features which will affect acoustic propagation or acoustic system performance (Undersea Remote Sensing DRI) and/or events which cause swimmer or navigational hazards (bathymetry-wave-current-wind interactions). Conduct studies using remote sensing of the coastal and riverine environment, above and below the sea surface and canopy, using electro-optic (EO), infrared (IR), radar, synthetic aperture radar (SAR),interferometric SAR (inSAR) and acoustic, from land or ship-based, unmanned vehicles, airplanes or satellites (Undersea Remote Sensing DRI). Develop new remote sensing tools and algorithms that can be used to initialize forecast models in distant, remote and/or denied areas. Conduct modeling and field studies of storm processes affecting the littoral environment, including the atmosphere, sea surface, water column, sea bed and suspended or dissolved materials. Predicting the initiation, transport and/or erosion of materials in response to storm events that create navigationally significant bathymetry or traffic-ability changes and/or changes in optical clarity. Marine Mammals and Biology					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Areas of research include monitoring and detection, integrated ecosystem, and effects of sound on marine mammals. Conduct basic research to develop and test new and existing technology to detect, classify, localize and potentially track marine mammals in the marine environment, which are used to develop density and abundance estimates of marine mammals as a required input for all Navy sound effects modeling done under mandate of the federal Marine Mammal Protection Act and National Environmental Policy Act. Conduct multidisciplinary studies including tagging, visual surveys, and passive acoustics to collect baseline measures of marine mammal behaviors and distributions relative to environmental features and marine mammal prey fields. These baseline measures provide a context for interpreting responses to naval acoustic sources. Also, continue research on the effects of sound include behavioral, physiological (hearing and stress response), and population-level consequences of sound exposure on marine life. Conduct research to characterize the gas management and kinetics (stores and use) in marine mammals. Conduct research using increase in funds to characterize and quantify the cumulative effects of multiple stressors on marine mammal populations. Conduct research to advance our understanding of sound reception mechanisms in mysticetes (large whales). Effects of Sound Research on behavioral, physiological (hearing and stress response), and potentially population-level consequences of sound exposure on marine life. Research to characterize the causal chain of events leading from sound exposure to biologically significant behavioral reactions that might increase risks of population-level effects and/or the potential for stranding. An additional focus is to characterize the gas management and kinetics (stores and use) in marine mammals. Research the mechanisms that enable marine mammals to dive to deep depths for long durations while mitigating, if not avoiding, health threats. Initiate research to advance our understanding of sound reception mechanisms in mysticetes (large whales) will require a thorough exploration of the anatomy surrounding the ear and the whole head combined with modeling sound propagation through various tissues of whale heads and/or bodies. Another research focus is to better understand the stress response in marine mammals to sound exposure. Research on understanding of the natural variation of stress markers, better understand and characterize the relationships among hormones or other biomarkers in different matrices, define and compare the quantitative and temporal relationships of hormones across the different matrices, and evaluate and characterize the relationship between the physiological stress response in marine mammals and acoustic exposure and biologically significant disturbance. Research to develop statistical models of the population consequences of acoustic disturbance to be fitted to data from marine mammal populations and lead collaborative development of transferable models of the effects of disturbance on marine mammals.					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Monitoring and Detection Research to develop and test new and existing technology to detect and classify marine mammals in the marine environment and during periods of low light such as passive acoustics, and infrared (IR). Research and development of passive acoustic signal processing algorithms for detection, classification, and localization of marine mammals. Continue the development and testing of autonomous hardware platforms using passive acoustics and/or IR to detect and classify marine mammals using a variety of fixed, towed, floating, and profiling platforms. Arctic sciences Research to improve the understanding of physical processes in the Arctic environment that impact current and projected Naval operations. Efforts include research to characterize the behavior of sea ice, including melt and reformation, ice rheology and motion, and interactions with ocean stratification, surface waves, and the atmosphere. The research program includes development of Arctic System models and data assimilation techniques for improved prediction, exploration and development of new sensors and unmanned platforms to collect observations of the Arctic environment, and the research into new algorithms to characterize sea ice from space-based remote sensing. An effort to better understand processes controlling the stratification of the Arctic Ocean will conclude this year. Ocean Acoustics Expand research to understand propagation and scattering of acoustic energy in a wide range of ocean environments. New emphasis will be placed on the information content contained in underwater acoustic signals for use in machine learning/big-data analytics. Areas of research include shallow-water scattering mechanisms related to reverberation and clutter; seabed acoustic measurements supporting geo-acoustic inversion; acoustic propagation through internal waves and coastal ocean processes and the development of unified ocean/seabed/acoustic models, including scattering from rough surfaces, biologics and bubbles; and penetration/propagation within the porous seafloor. In deep water research will include the effects of environmental variability induced by ocean internal waves, internal tides and mesoscale processes, and by bathymetric features including seamounts and ridges, on the stability, statistics, spatial distribution, and predictability of broadband acoustic signals. Also of interest is the coherence and depth dependence of deep-water ambient noise. An increasing emphasis will be placed on understanding the effects of Arctic conditions on acoustic propagation and ambient noise, particularly in under-ice environments, as facilitated by a basin wide data collection effort scheduled to begin in FY 2020.					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total

Battlespace Environments

The overall objective of this research is to improve basic understanding of physical, seafloor and biological oceanographic processes on space and time scales of naval interest. The work includes studies of aspects of ocean
circulation (fronts, eddies and turbulence), thermodynamics (mixing and acoustic impacts), waves (including their impact on sea ice and rogue waves), sea ice (including land fast ice) as well as ocean boundary layer processes.
Emphasis is on improved measurements, laboratory and model based experiments to quantify and understand important oceanographic processes that lead to the development of ocean dynamic/thermodynamic models from global to submesoscale
scales, and to couple these oceanographic models with atmospheric, ice, biological, sediment response, and optical models. Surveillance of coastal land areas and waters is important to support Navy operations, so the research
foci include an improved use of overhead (airborne and satellite) active and passive microwave sensors, overhead optical sensors, surface-based (ships and ground-based) grazing angle microwave sensors. To predict bottom boundary
physical, geological, geochemical, geoacoustic and geotechnical properties in shallow-water operating areas requires: a) an improved understanding of processes that generate and modify the shape, structure and physical properties of the seafloor, subsea floor, ocean water column and ice-cover and topography/morphology; b) use of rapid, airborne characterization of littoral environments including time-varying coastal topography, littoral bathymetry, sea-level height, land and seafloor sedimentary structures to explain/predict the observed changes; c) remote sensing of bulk properties of Arctic sea-ice over broad two-dimensional areas that previously could be sampled only at spot
locations by in-situ sampling; and d) quantification of the influence of turbulence generated at the seafloor boundary layer on vertical mixing and stratification in shallow water outside the surf zone.

FY 2020 OCO Plans:
N/A

FY 2019 to FY 2020 Increase/Decrease Statement:
The funding increase from FY 2019 to FY 2020 is a result of the realignment of funds within the PE from Basic Research Challenge program into Ocean Sciences Activity to better identify and continue understanding the effects of Arctic conditions on acoustic propagation and ambient noise, particularly in under-ice environments,

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
as facilitated by a basin-wide data collection effort scheduled to begin in FY 2020. These efforts were initiated as part of the FY 2019 Basic Research Challenge program.					
Title: SCIENCE AND ENGINEERING EDUCATION, CAREER DEVELOPMENT AND OUTREACH	48.639	44.229	49.014	0.000	49.014
Description: Science and Engineering Education and Career Development activities include Department of the Navy (DON) participation in science fairs, summer research interns/fellows at Navy laboratories, graduate fellowships for individuals expected to become members of the engineering faculty at Historically Black Colleges and Universities and Minority Institutions (HBCU/MIs), and curricular enrichment programs. It is centered on Naval S&T efforts supporting Science, Technology, Engineering and Math (STEM). Outreach includes the encouragement, promotion, planning, coordination and administration of Naval Science and Technology. The Department of the Navy's (DON) Historically Black Colleges and Universities/Minority Institutions (HBCU/MI) program oversees the Navy's efforts to engage and support our nation's HBCU/MIs and is responsible for developing and managing efforts that strengthen and support the capabilities of HBCU/MIs to participate in basic, applied, and advanced research programs within the Naval Research Enterprise (NRE). SCHOOLHOUSE TRAINING: Discovery research on instructional strategies and techniques for schoolhouse training including virtual, augmented, and mixed reality environments. Correlate effective schoolhouse training and measures of downstream performance, including development of theories into skill acquisition and decay. The ONR Young Investigator Program (YIP) was established in 1985 to attract outstanding faculty members to the Department of Navy's basic research program by identifying individuals that show exceptional promise for doing creative research and encourage their teaching and research careers through long term support. Young Investigator awards are for a period of three years. Annual request for proposals are solicited via a funding opportunity announcement and is open to tenure-track faculty in science, engineering, and mathematics. Topics are competitively selected based on faculty achievements, technical proposal, benefit to the Navy and Marine Corps, and institution support. Naval Research Institution:Through a Memorandum of Understanding between the United States Naval Academy (USNA) and the Office of Naval Research, this program contributes to the technical education of midshipmen by providing an opportunity to enhance their experience in research and knowledge of the positive impact that understanding of Science, Technology, Engineering, and Mathematics (STEM) has on fleet and forces capabilities.					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Funding also supports the Office of Naval Research (ONR) Global mission to serve as the preeminent external facilitator for the NRE. This is accomplished by establishing quality, relevant connections between the international research and development community, Naval fleet/forces, Department of Defense (DOD), other US Government agencies and international partners. The direct impact of this investment is to leverage international basic research during increasingly dynamic global interdependence and improve the ability to solve DON Science & Technology challenges through shared knowledge with partners. Accomplishments and plans described below are examples for each effort category. ***FY 2019 Plans:*** Support STEM initiatives and multi-year efforts that are intended to be approximately three years in length and in topics supporting STEM education relevant to naval science and technology workforce development. Start development of pilot efforts to improve STEM through the development of new curricula and experiential learning activities that respond to new naval Science and Technology personnel and knowledge needs. Expand existing successes to scale working projects and achieve greater impact and implementation of funded efforts. Support new activities to targeting regional efforts to drive greater impact on educational systems and increase workforce opportunity for the naval Science and Technology community. Continue coordination of DON STEM efforts. Enhance and maximize HBCU/MIs faculty and student awareness of STEM and other defense-related educational research opportunities to make significant contributions to Naval Research Enterprise. Support efforts to provide student internships and faculty fellowships that will increase the capability of Science and Technology efforts into a new age of discovery. ONR Global will continue fostering international collaboration and issuing basic research grants. ***FY 2020 Base Plans:*** Support Science, Technology, Education and Mathematics (STEM) initiatives and multi-year efforts that are intended to be approximately three years in length and in topics supporting STEM education relevant to naval science and technology workforce development. Start development of pilot efforts to improve STEM through the development of new curricula and experiential learning activities that respond to new naval Science and Technology personnel and knowledge needs. Expand existing successes to scale working projects and achieve greater impact and implementation of funded efforts. Support new activities to targeting regional efforts to drive greater impact on educational systems and increase workforce opportunity for the naval Science and Technology community. Continue coordination of Department of the Navy (DON) STEM efforts.					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
This effort will continue to support programs that provide hands-on research experiences in STEM fields for United States Naval Academy (USNA) midshipmen and faculty members to enhance the midshipmen's educational environment at the USNA. Enhance and maximize HBCU/MI's faculty and student awareness of STEM and other defense-related educational research opportunities to make significant contributions to the NRE by increasing the number of students and faculty participating in DoN HBCU/MI fellowships and internships and increasing the number of Research and Development grants awarded by the DoN HBCU/MI Program to HBCU/MIs. Support efforts to provide student internships and faculty fellowships that will increase the capability of Science and Technology efforts into a new age of discovery. Ongoing efforts include attracting student veterans to research and career opportunities in STEM related fields. 25 to 35 Young Investigators are selected for award annually from the many proposals received. Ongoing efforts cover a wide range of topics of naval S&T interest. Recent topics include innovative technical approaches to: vortex flow in hypersonic aerodynamics; real-time accurate positioning in robotics, acoustic meta-materials for marine surfaces, cyclone intensity forecasting, advanced mathematical optimization for statistical applications, cephalopod inspired camouflage, digitization of human performance, soil characterization capability from remote sensing, thermal transport at solid-solid interfaces, and high-temperature multi-principal alloys. These and other research topics will benefit today's and the next generation warfighter by improving lethality, survivability, communications, and training. Additionally, many of these investigators will provide long-term support and knowledge in solving naval related S&T challenges. ONR Global will foster collaboration with international organizations and researchers by awarding grants in innovative basic research to discover, access and assess revolutionary, high-payoff technologies for future Naval missions and capabilities. SCHOOLHOUSE TRAINING: Discovery research efforts include: (i) Developing optimized training and retention models; (ii) Designing better training schedules; and (iii) Developing skill tutors for maintenance tasks. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increase from FY 2019 to FY 2020 is a result of the realignment of funds from within this PE, Basic Research Challenge Activity into the Science and Engineering Education, Career Development and Outreach					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Activity, to better identify and continue Science and Engineering Education, Career Development and Outreach effort(s) initiated as part of the FY 2019 Basic Research Challenge program.					
Title: SENSORS, ELECTRONICS AND ELECTRONIC WARFARE (EW)	48.645	48.386	48.804	0.000	48.804
Description: Efforts include the basic research portions of: sensing, diagnostics, and detectors; navigation and timekeeping; nanoelectronics; wide band gap power devices; real-time targeting; Electro-Optical/Infra-Red (EO/IR) electronics; EO/IR electronic warfare; EO/IR sensors for surface/aerospace surveillance; Radio Frequency (RF) sensors for surface/aerospace surveillance; solid state electronics; vacuum electronics; and RF electronic warfare. Accomplishments and plans described below are examples for each effort category. ***FY 2019 Plans:*** Expanded the efforts identified within Undersea Warfare, Electromagnetic Warfare, and Materials and Chemistry Sensors, Electronics and Electronic Warfare (SEEW) Conduct basic research in the areas of solid state transistors and devices for high frequency analog and digital operation; high efficiency, highly linear amplifiers for microwave, millimeter-wave, low-noise, and power applications; superconducting and other technologies which are designed to deliver software defined, wide band, simultaneous signal functionality for conventional system contexts, including, but not limited to, satellite communications (SATCOM), Surveillance, Electronic Warfare (EW), signal intelligence (SIGINT), and communications; electronics and photonics technology that provides for the control, reception, transmission and processing of signals; and continue research to advance navigation, timekeeping and sensing technology, including cooling and trapping of atoms and ions; Bose-Einstein condensation and coherent matter- wave physics; optically-based frequency standards; improved time and frequency metrology using quantum entanglement and quantum logic processing; quantum optomechanics; and coherence and control of quantum systems. Electronics					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Create new knowledge and understanding and explore new concepts, components, techniques and methods, for the design, growth, and characterization of electronic, electromagnetic, and electro-optical materials, fabrication processes, electronic and electro-optic components, including novel electromagnetic concepts and techniques, and plasma phenomena and theory. Electromagnetic Warfare Fundamental research is being conducted looking at revolutionary mechanisms for advanced tracking techniques for the joint battle space. A very novel concept of using radars for long range speech reception and playback is ongoing. RCS prediction capabilities for naval vessels is being researched to cover ultra-wide bandwidths, significantly expanding our predictive narrow band capabilities. Other promising avenues of research will allow for asymmetric warfare through image recovery in previously denied conditions, provide the necessary theoretical foundation and produce algorithmic tools for performing target detection and discrimination via multiple resource constrained antennas operating in highly cluttered environments, and significantly improve the ability to track extremely maneuverable targets and handle nonlinear measurements in radar and sonar systems. Materials and Chemistry Design novel experiments and theoretical models to create advanced or improved materials using new concepts and techniques for applications and sensors and advanced electronics. Improve target identification algorithms utilizing nonlinear dynamics. Understand and demonstrate the principles and mechanisms of DNA-based molecular-scale machines to amplify detection of biochemical agents. Fabricate single atomic layer of materials to create 2-dimensional ferromagnets and semiconductors. The material of choice will be single layer MoS2 for utilization as indirect gap semiconductors. The Navy unique single stage accelerator mass spectrometer to evaluate the fine scale detection limits of fusion products and isotopes. Understand protein-surface interactions leading highly sensitive biosensors. First principle theoretical models are developed to understand the principles governing the interactions between surfaces and small molecules. Previous studies in these areas have demonstrated success in designing biological and chemical sensors with parts per trillion sensitivity as well as understanding of electronic mobility of graphene due to the effects of edge and defects. Undersea Warfare					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Perform laboratory, field, and theoretical/numerical studies to investigate physical phenomenon related to acoustic propagation and scattering in oceanic environments such as: approaches to predict the scattering signature of a structure using noise sources of opportunity; investigate the fundamental physical phenomena of wave propagation in ocean environments; and approaches to separate of an acoustical field from turbulent flow on an acoustic array. ***FY 2020 Base Plans:*** Sensors, Electronics and Electronic Warfare (SEEW) Conduct basic research in the areas of solid state transistors and devices for high frequency analog and digital operation; high efficiency, highly linear amplifiers for microwave, millimeter-wave, low-noise, and power applications; superconducting and other technologies which are designed to deliver software defined, wide band, simultaneous signal functionality for conventional system contexts, including, but not limited to, satellite communications (SATCOM), Surveillance, Electronic Warfare (EW), signal intelligence (SIGINT), and communications; electronics and photonics technology that provides for the control, reception, transmission and processing of signals; and continue research to advance navigation, timekeeping and sensing technology, including cooling and trapping of atoms and ions; Bose-Einstein condensation and coherent matter- wave physics; optically-based frequency standards; improved time and frequency metrology using quantum entanglement and quantum logic processing; quantum optomechanics; and coherence and control of quantum systems. Electronics Create new knowledge and understanding and explore new concepts, components, techniques and methods, for the design, growth, and characterization of electronic, electromagnetic, quantum phenomenology, and electro-optical materials, fabrication processes, electronic and electro-optic components, including novel electromagnetic concepts and techniques, and plasma phenomena and theory. Create new knowledge and understanding for quantum computing algorithms and their use to create new understanding of materials by design, process optimization, and quantum simulation. Electromagnetic Warfare Fundamental research is being conducted looking at a very novel concept of using radars for long range speech reception and playback is ongoing. Radar Cross Section (RCS) prediction capabilities for naval vessels is being					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
researched to cover ultra-wide bandwidths, significantly expanding our predictive narrow band capabilities. When coupled with another developmental effort on multistatic radar theory will provide a broad perspective of target signatures essential to defining radar and EW performance requirements. Research in the Electro-Optical/Infra-Red (EO/IR) domain will demonstrate new filtering technique enabling 30x gain in sensitivity and 3x gain in resolution for multi-color image sensors. Materials and Chemistry Design novel experiments and theoretical models to create advanced or improved materials using new concepts and techniques for applications and sensors and advanced electronics. Improve target identification algorithms utilizing nonlinear dynamics. Understand and demonstrate the principles and mechanisms of DNA-based molecular-scale machines to amplify detection of biochemical agents. Fabricate single atomic layer of materials to create 2-dimensional ferromagnets and semiconductors. The material of choice will be single layer Molybdenum disulfide (MoS2) for utilization as indirect gap semiconductors. The Navy unique single stage accelerator mass spectrometer to evaluate the fine scale detection limits of fusion products and isotopes. Understand protein-surface interactions leading highly sensitive biosensors. First principle theoretical models are developed to understand the principles governing the interactions between surfaces and small molecules. Previous studies in these areas have demonstrated success in designing biological and chemical sensors with parts per trillion sensitivity as well as understanding of electronic mobility of graphene due to the effects of edge and defects. Undersea Warfare Laboratory, field, and theoretical/numerical studies to investigate physical phenomenon related to acoustic propagation and scattering in oceanic environments such as: prediction of the scattering signature of a structure using noise sources of opportunity; fundamental physical phenomena of wave propagation in ocean environments; approaches to separate of an acoustical field from turbulent flow on an acoustic array; and new structural acoustics theory. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:***					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
There is no significant change from FY 2019 to FY 2020.					
Title: WEAPONS	18.502	20.306	23.419	0.000	23.419
Description: This Program focuses on a number of fundamental scientific areas that are aimed at expanding the underlying understanding of disciplines that are broadly useful for a wide range of Naval applications, including: undersea weaponry; air weaponry; energetic materials and solid rocket propulsion; expeditionary operations, including communications, materials, landmine detection, human sensory enhancements, lightweight power sources and information efficiency; directed energy and counter directed energy, hypersonic aerodynamics and materials, and applied electromagnetics. This activity includes peer-review basic research to develop fundamental knowledge and enhance the science and engineering workforce and technology base. ***FY 2019 Plans:*** Research will focus on undersea weaponry; energetic materials and propulsion; expeditionary operations (communications, materials for forensic sensing, landmine detection, human sensory enhancements, lightweight power sources and information efficiency); directed energy, counter directed energy and applied electromagnetics hypersonics. Energetic Materials and Propulsion Conduct basic research into the science of energetic materials and advanced propulsion technology. Researched advanced energetic material which provide reactive, explosive, and propulsive phenomena including high energy ingredient synthesis, modeling, characterization, and the fundamentals of initiation and decomposition mechanisms. Program has explored the bounds of energy management between conventional electron bonding energies and that of nuclear binding energies. Current investigations focus on both theoretical and experimental processes using molecular design and crystal morphology theory for the selection of new insensitive munition (IM)-compliant commodity energetic material ingredients. Investigate development of a new methodology coordinating both theoretical and synthetic chemistry to maximize molecular design and predicted molecule stabilities facilitating insight into the next generation of energetic materials including research to develop ability to synthesize and quantitatively predict energetic material performance. Pursue research into sub-nano scale molecular systems and the energetic phenomena including initiation techniques, novel nozzle, tube and flow approaches, and sensing and propulsive control technology. Investigating efforts to explore alternative fuel concepts for Naval applications to include hydrogen, electric propulsion, synthetic diesel, and biodiesel. Conduct basic research into solid rocket motor system technologies for increased range, speed, improved stealth, and maneuverability. Pursuing research into Rotating Detonation Engines (RDEs) and their					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
application to air vehicles and weapons including detonation initiation techniques, low-loss combustor isolation, fuel-air mixing, tube and flow approaches, and sensing and control technology. Undersea Weaponry Pursue advanced concepts for sea warfare and weapons to include conducting basic science and research to explore new ideas and technologies to enhance the performance of existing power & energy sources, undersea weapons, unmanned vehicles, aircraft, ships and submarines for the Navy. Expand autonomous control technology for surface and subsurface vehicles. Directed Energy Explore the scientific limitations of laser technology for utilization at tactically significant ranges. The goals of the program include research of laser sources, adaptive optic compensation techniques, understanding of long range atmospheric propagation physics, and characterization of laser-matter interactions. This program will lead to understanding which DE is best for Naval defense applications. Counter Directed Energy Investigate ability to counter directed energy weapons in high energy lasers or high power radiofrequency devices. Conduct performance assessments of laboratory components in phased experimentation on laser and High Power Microwave protection methods for future naval aviation and surface ship systems and platforms. Hypersonics Basic research will address long-range weapon components able to survive high temperature exposure for several minutes and thwart anti-access/ area denial countermeasures. Additional areas of research include Boundary layer physics in shock-wave dominated flows around highly-swept or slender bodies, Aero-thermo-elastic and/or aero-servo-elastic effects arising from control surface actuation at high speeds, descriptions of high-speed boundary layer transition that unify theories across disparate external conditions, novel strategies for extending regions of laminar flow and advanced hypersonic aerodynamic design tools that incorporate modern					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601153N / *Defense Research Sciences*	**Project (Number/Name)** 0000 / *Defense Research Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
predictions of transition pathways, freestream noise contributions, time/heating-dependent surface finish effects, and unsteady aerodynamics. ***FY 2020 Base Plans:*** Research will focus on undersea weaponry; energetic materials and rocket propulsion; directed energy, counter directed energy, applied electromagnetics, and hypersonics. Undersea Weaponry Pursue advanced concepts for sea warfare and weapons to include conducting basic science and research to explore new ideas and technologies to enhance the performance of existing power & energy sources, undersea weapons, unmanned vehicles, aircraft, ships and submarines for the Navy. Sunset efforts on supercavitation and expand autonomous control technology for surface and subsurface vehicles and weapons. Air Weaponry Research will focus on the areas of solid and hybrid rocket propulsion, advanced structural and aperture materials, navigation, aerodynamics, single and multi-missile control, and power management. This effort will enable missiles with greatly increased speed, range and lethality to meet future naval warfare needs. Directed Energy Research will focus on the scientific limitations of laser technology for utilization at tactically significant ranges. The goals of the program include research of laser sources, adaptive optics compensation techniques, understanding of long range atmospheric propagation physics, and characterization of laser-matter interactions. This program will lead to understanding which directed energy (DE) is best for Naval defense applications. Counter Directed Energy Research will investigate ability to counter directed energy weapons in high energy lasers or high power radiofrequency devices. Analytical models, modeling and simulation, and laboratory experiments on laser and High Power Microwave protection methods for future naval aviation, missiles, and surface ship systems and platforms. Energetic Materials and Rocket Propulsion Research will investigate new energetic chemical compounds with superior specific energy and energy density, brisance, insensitivity, etc. for useful warhead fills and solid rocket propellants. Methods for improved					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601153N / *Defense Research Sciences*	**Project (Number/Name)** 0000 / *Defense Research Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
understanding of formulations and advanced modeling and simulations on composite energetic materials will be investigated along with new methods and instruments for characterization. Hypersonics Research will address the fundamental understanding of the underlying phenomena unique to hypersonic flight where extreme temperatures and other unique flow and material conditions arise. Areas of research include boundary layer physics in shockwave dominated flows around highly-swept or slender bodies, Aero-thermo-elastic and/or aero-servo-elastic effects arising from control surface actuation at high speeds, descriptions of high-speed boundary layer transition that unify theories across disparate external conditions, novel strategies for extending regions of laminar flow and advanced hypersonic aerodynamic design tools that incorporate modern predictions of transition pathways, freestream noise contributions, time/heating dependent surface finish effects, and unsteady aerodynamics. Ultra-high temperature materials, coatings, and thermal protection systems will also be investigated. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increase from FY 2019 to FY 2020 is a result of the realignment of funds within the PE from Basic Research Challenge program into Weapons Activity to better identify and continue basic research in the areas of solid and hybrid rocket propulsion, advanced structural and aperture materials, navigation, aerodynamics, single and multi-missile control, and power management effort(s) initiated as part of the FY 2019 Basic Research Challenge program.					
Title: BASIC RESEARCH CHALLENGE ***Description:*** The ONR Basic Research Challenge (BRC) program was established in 2008 to competitively select and fund promising research programs in new areas not addressed by the current basic research program. The program stimulates new, high-risk basic research projects in multidisciplinary and departmental collaborative efforts, and funds topics that foster leading edge science and attract new principal investigators and organizations. Basic Research Challenge awards are for a period of four years. Topics are submitted by Office of Naval Research (ONR) program officers and are selected for BRC awards. Basic Research Challenge award topics are then issued as a broad agency announcement. ***FY 2019 Plans:***	20.918	22.059	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601153N / *Defense Research Sciences*	**Project (Number/Name)** 0000 / *Defense Research Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Conduct basic research into, high-risk multidisciplinary research areas including: autonomy, de-centralized on-line optimization, carbon molecular electronics, co-prime sensor array signal processing, small unit decision making training, biologically inspired flow field computation, algorithm optimization for multi-physics based models, composite explosive compounds, advanced analysis techniques for materials, and active supersonic jet noise control. Conduct basic research topics in emerging fields of science including: multiscale theory for cavitation in complex soft materials; phase-resolved bottom-side IONosphere (BSION); decentralized perception in data-rich dynamic environments; enhanced manufacturability with electrical currents; distributed sensing, actuation and control in soft materials for flexible appendages; predictive and causal modeling; and new opportunities to transform wall-bounded turbulence understanding. ***FY 2020 Base Plans:*** Beginning in FY 2020, the Basic Research Challenge program resources have been realigned into associated research efforts across the basic research portfolio to better align these resources with Navy Basic Research opportunities and priorities. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding decrease from FY 2019 to FY 2020 is a result of the realignment of funds from within this PE from Basic Research Challenge Activity into Weapons; Mathematics Activity, Computer & Information Sciences; Human Systems Activity; Ocean Sciences;Science and Engineering Education, Career Development and Outreach Activity; and Science Addressing Hybrid Threats Activity to better identify and continue specific efforts associated with those Activities as initiated as part of the FY 2019 Basic Research Challenge program.					
Accomplishments/Planned Programs Subtotals	448.084	458.602	470.007	0.000	470.007

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601153N / *Defense Research Sciences*	**Project (Number/Name)** 0000 / *Defense Research Sciences*

E. Performance Metrics

Defense Basic Research seeks to improve the quality of defense research conducted predominantly through universities and government laboratories. It also supports the education of engineers and scientists in disciplines critical to national defense needs through the development of new knowledge in an academic environment. Initial research focus is generally conducted in an unfettered environment because of the nature of basic research, but as more is learned and applications emerge, individual research projects take on a more applied focus. Individual project metrics then become more tailored to the needs of specific applied research and advanced development programs. Example metrics include a biporous wick structure for thermal management of power electric modules capable of removing 900 watts per square centimeter which was recently developed by an academia/industry team. The National Research Council of the National Academies of Science and Engineering's congressionally directed "Assessment of Department of Defense Basic Research" concluded that the DoD is managing its basic research program effectively.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319 / 1					R-1 Program Element (Number/Name) PE 0601153N / *Defense Research Sciences*				Project (Number/Name) 9999 / *Congressional Adds*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
9999: *Congressional Adds*	0.000	0.000	40.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	40.500

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Basic Research ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Conduct basic research efforts including scientific study and experimentation directed toward increasing knowledge and understanding in national security related aspects of physical, engineering, environmental and life sciences. Basic research effort subject areas include: Autonomous Systems; Artificial Intelligence/Machine Learning; Command, Control, Communications and Computers (C4); Marine as a System; Information Analysis and Decision Support; Intelligence, Surveillance and Reconnaissance; Logistics; Materials; Operational Environments; Platforms; Power and Energy Technology; Sensors and Electronics; Warrior Performance and Protection; Weapons and Support (Education and Outreach).	0.000	35.000
Congressional Add: Navy ROTC Cybersecurity Training Program ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Explore and implement a collegiate program to train Navy ROTC and civilian students to be able to provide and enhance Naval cybersecurity as military or civilian experts. Funding will also support professorial mentoring and continued education outreach.	0.000	5.500
Congressional Adds Subtotals	0.000	40.500

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 1	**R-1 Program Element (Number/Name)** PE 0601153N / *Defense Research Sciences*	**Project (Number/Name)** 9999 / *Congressional Adds*

E. Performance Metrics

Congressional Interest Items not included in other Projects.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602114N / *Power Proj Applied Research*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	23.028	27.643	18.546	-	18.546	19.583	23.743	25.048	29.341	Continuing	Continuing
0000: *Power Proj Applied Research*	0.000	13.372	14.643	18.546	-	18.546	19.583	23.743	25.048	29.341	Continuing	Continuing
9999: *Congressional Adds*	0.000	9.656	13.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	22.656

A. Mission Description and Budget Item Justification

The efforts described in this Program Element (PE) are based on investment directions as defined in the Naval Research and Development Framework. This strategy is based on needs and capabilities from Navy and Marine Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It provides the vision and key objectives for the essential science and technology efforts that will enable the continued supremacy of U.S. Naval forces in the 21st century. The Strategy focuses and aligns Naval S&T with Naval missions and future capability needs that address the complex challenges presented by both rising peer competitors and irregular/asymmetric warfare.

This PE supports both advanced technology research and near to mid-term transition opportunities. The advanced research focus is primarily on directed energy, high speed weapon propulsion, and electro-optic/infrared (EO/IR) sensor technologies.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Program Change Summary ($ in Millions)	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**
Previous President's Budget	13.553	14.643	14.610	-	14.610
Current President's Budget	23.028	27.643	18.546	-	18.546
Total Adjustments	9.475	13.000	3.936	-	3.936
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	13.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.524	0.000			
• Program Adjustments	0.000	0.000	3.936	-	3.936
• Rate/Misc Adjustments	-0.001	0.000	0.000	-	0.000
• Congressional Add Adjustments	10.000	-	-	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602114N *I Power Proj Applied Research*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *High Performance Microwave for Counter-IED Research*	4.828	9.000
Congressional Add: *Adaptive Optics*	4.828	0.000
Congressional Add: *Directed Energy*	0.000	4.000
Congressional Add Subtotals for Project: 9999	9.656	13.000
Congressional Add Totals for all Projects	9.656	13.000

Change Summary Explanation

The program increase in FY 2020 is associated with an increased concentration on the applied research of Air Weapons.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602114N / *Power Proj Applied Research*	Project (Number/Name) 0000 / *Power Proj Applied Research*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *Power Proj Applied Research*	0.000	13.372	14.643	18.546	-	18.546	19.583	23.743	25.048	29.341	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project addresses the technology issues involving the Navy's capability to project naval power on the broad seas and in the littoral regions.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: DIRECTED ENERGY	4.494	6.463	6.427	0.000	6.427
Description: The goal of this activity is to develop Directed Energy technology for Navy applications. The DE program addresses the requirements of future Navy combatants to provide ship defense against the emerging threats that are proliferating throughout the Navies of the world. The Directed Energy portion of this activity consists of two elements.					
FY 2019 Plans: Directed Energy Research: Continue research and thrusts in component technologies and basic understanding of laser/material interactions to enable higher power, more lethal High Energy Laser, high power Microwave/Radio Frequency, and Ultra Short Pulse Laser weapons capabilities. Some examples of research include the development of novel laser and beam directory architectures, improved sensor and illuminator technologies including materials and coating, improved HEL electrical to optical efficiency, improved laser sources with enhanced spectrum control, reduced system jitter and improved precision aim point maintenance. Other research areas that will be explored are the syntheses of target recognition, pose/trajectory estimation, autonomous aim point selection and maintenance including tracking through intermittent viewing conditions such as waves and clouds, understanding atmospheric characterization and modeling tools, blooming, laser/material/target interactions, novel laser sources in Medium Wavelength Infrared (MWIR) and the Long Wavelength Infrared (LWIR)-(4-12 microns), USPL propagations and effects. Research will continue in Counter Directed Energy Weapons (CDEW), in response to the development of high energy laser (HEL) and high-power microwave (HPM)/high-power radio frequency (HPRF) threats. Complete effort to develop a fiber based high power laser operating in the eye safe regime beyond 2 microns.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602114N / *Power Proj Applied Research*	**Project (Number/Name)** 0000 / *Power Proj Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Electronics: Continue applied research efforts to apply innovative Science and Technology (S&T) in plasmas, pulsed power, electromagnetic acceleration, particle beams, high-energy & Ultra Short Pulse Lasers (USPL), and non-linear optics to support current and future Navy and DoD needs. ***FY 2020 Base Plans:*** Conduct research efforts and thrusts in component technologies and basic understanding of laser/material interactions to enable higher power, more lethal High Energy Laser (HEL), high power Microwave/Radio Frequency, and Ultra Short Pulse Laser (USPL) weapons capabilities. Some examples of research include the development of novel laser and beam directory architectures, improved sensor and illuminator technologies including materials and coating, improved HEL electrical to optical efficiency, improved laser sources with enhanced spectrum control, reduced system jitter and improved precision aim point maintenance. Other research areas that will be explored are the syntheses of target recognition, pose/trajectory estimation, autonomous aim point selection and maintenance including tracking through intermittent viewing conditions such as waves and clouds, understanding atmospheric characterization and modeling tools, blooming, laser/material/ target interactions, novel laser sources in Medium Wavelength Infrared (MWIR) and the Long Wavelength Infrared, USPL propagations and effects. Research will continue in Counter Directed Energy Weapons (CDEW), in response to the development of HEL and high-power microwave (HPM) and high-power radio frequency threats. Complete effort to develop a fiber based high power laser operating in the eye safe regime beyond 2 microns. Electronics: Conduct applied research efforts to apply innovative Science and Technology (S&T) in plasmas, pulsed power, electromagnetic acceleration, particle beams, high-energy & Ultra Short Pulse Lasers, and non-linear optics to support current and future Navy and DoD needs. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: HIGH SPEED PROPULSION AND ADVANCED WEAPON TECHNOLOGIES ***Description:*** Applied Research into a wide range of technologies that support high speed weapons work in this activity is focused on demonstrating propulsion and vehicle technologies for Mach 3 to Mach 8 or beyond capable weapons. This work includes technologies associated with high-acceleration projectile structures, high temperature and high strength materials to enable projectiles to survive high-speed launch environment,	4.649	3.878	7.774	0.000	7.774

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602114N / *Power Proj Applied Research*	**Project (Number/Name)** 0000 / *Power Proj Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
improved thermal prediction methodologies and test techniques, wide dynamic pressure adaptable projectile controls and non-explosively launched lethal mechanisms. The high speed projectile technologies are intended to support long range Naval Surface Fire Support weapons. ***FY 2019 Plans:*** Continue current investments to include topics relevant for development of high speed/hypersonic aerodynamics technologies to support exploratory development to enable very long range hypersonic boost-glide missiles and hypersonic ship-launched projectiles. Specific research and development plans include continued development of very long range hypersonic boost-glide missiles and hypersonic ship-launched projectiles; advanced computational and experimental techniques for hypersonic boundary layer transition; high temperature thermal management research; ultra-high temperature materials research for hypersonic leading edges and nose tips; technology maturation of advanced airframes and controls; high Gforce components and miniaturization of electronics; advanced guidance and control technologies for high speed weapons; insulator and ablative technology investigations; high speed propulsion and integrated airframe technology development to enhance system range, responsiveness, and reliability; and advanced material solutions to high speed airframes and air systems operating in maritime environments. ***FY 2020 Base Plans:*** Investments to include topics relevant for development of high speed propulsion for solid rocket motors and hybrid type propulsion technologies such as solid-fuel ramjets for greatly enhanced projectile range and missiles. High-speed and hypersonic external aerodynamic technologies will be investigated to support future development efforts to enable hypersonic boost-glide missiles and hypersonic ship-launched projectiles. Specific research and development plans include continued development of very long range hypersonic boost-glide missiles and hypersonic ship-launched projectiles; advanced computational and experimental techniques for hypersonic boundary layer transition; high temperature thermal management research; ultra-high temperature materials research for hypersonic leading edges and nose tips; technology maturation of advanced airframes and controls; high G-force components and miniaturization of electronics; advanced guidance and control technologies for high speed weapons; insulator and ablative technology investigations; high speed propulsion and integrated airframe technology development to enhance system range, responsiveness, and					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602114N / *Power Proj Applied Research*	**Project (Number/Name)** 0000 / *Power Proj Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
reliability; and advanced material solutions to high speed airframes and air systems operating in maritime environments. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increases from FY 2019 to FY 2020 are associated with an increased concentration on the applied research of Air Weapons such as hypersonic ship launched strike weapons.					
Title: NAVIGATION, ELECTRO OPTIC/INFRARED (EO/IR), AND SENSOR TECHNOLOGIES ***Description:*** This activity describes Navy Science and Technology investments in the areas of Electro Optic/ Infrared (EO/IR) devices and advanced sensors and includes investment/performance in the technology areas of EO/IR, Electronic Warfare (EW), Electromagnetic Warfare, and Communications. ***FY 2019 Plans:*** Electronics: Efforts to create and explore new concepts, components, techniques, and subsystems for the detection of UV, visible, and infrared radiation to support current and future Navy and DoD needs. Electromagnetic Warfare: Conduct multiple efforts to address the necessary technologies to engage Electro Optic/Infrared (EO/IR) threats through both active and passive countermeasures technologies and assuring deployment capabilities are available to achieve the proper disposition of materials for extended durations. Recent results in the application of new material concepts applied to IR concepts have received interest for potential follow on consideration pending successful demonstrations. ***FY 2020 Base Plans:*** Electronics: Create and explore new concepts, components, techniques, and subsystems for the detection of Ultra-violet (UV), visible, and infrared radiation to support current and future Navy and DoD needs with attention given to quantum enabled precise time, and magnetic and gravimetric sensing. Electromagnetic Warfare: Multiple efforts will be executed to address the necessary technologies to engage Electro Optic/Infrared threats through both active and passive countermeasures technologies and assuring deployment capabilities are available to achieve the proper disposition of materials for extended durations.	2.521	2.570	2.596	0.000	2.596

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602114N / *Power Proj Applied Research*	**Project (Number/Name)** 0000 / *Power Proj Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Recent results in the application of new material concepts applied to IR concepts have received interest for potential follow on consideration pending successful demonstrations. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: STRIKE AND LITTORAL COMBAT TECHNOLOGIES ***Description:*** The focus of this activity is on those technologies that will support Naval Precision Strike Operations and provide the Navy of the future the ability to quickly locate, target, and strike critical targets ashore. ***FY 2019 Plans:*** Electromagnetic Warfare: Technology development is ongoing to address capabilities to understand the defeat mechanism for operations of ISR platforms using non-traditional frequencies as well as protecting current capabilities against electronic attack through enhanced concepts. ***FY 2020 Base Plans:*** Electromagnetic Warfare: Technology development is ongoing to address capabilities to understand the defeat mechanism for operations of Intelligence Surveillance and Reconnaissance (ISR) platforms using non-traditional frequencies as well as protecting current capabilities against electronic attack through enhanced concepts. The non-traditional integration of ISR capabilities is being implemented into a major Commercialization Pilot Programs (CPP) funded effort at NRL to validate expectations at minimal cost to this program and expand the capability of a significant testing resource. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.	1.708	1.732	1.749	0.000	1.749
Accomplishments/Planned Programs Subtotals	13.372	14.643	18.546	0.000	18.546

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602114N / *Power Proj Applied Research*	**Project (Number/Name)** 0000 / *Power Proj Applied Research*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

This Program Element (PE) develops early component technologies that can be integrated into weapon systems that meet warfighter requirements. Most of the work in this PE can be classified between Technology Readiness Level (TRL) 2 (technology concept and/or application formulation) and TRL 4 (component and/or breadboard validation in laboratory environments). The metrics used to evaluate 6.2 programs are necessarily less precise than those used in 6.3 programs.

The metrics for this PE can be divided into two categories: technological and organizational/functional. Technological metrics address the success of the work performed. The primary technological metrics used in this PE involve laboratory experiments/tests demonstrating proof of the concept for the technology. This demonstration is frequently a hand-assembled functioning breadboard of the concept. The organizational/functional metrics applied to this PE include: transition of the technology to advanced development in a 6.3 PE and applicability of the technology to documented warfighter problems or requirements. Successful implementation of these categories would result in the application of a pass/fail metric and further evaluation for possible transition to a 6.3 development/demonstration program.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602114N / *Power Proj Applied Research*				Project (Number/Name) 9999 / *Congressional Adds*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
9999: *Congressional Adds*	0.000	9.656	13.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	22.656

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: High Performance Microwave for Counter-IED Research ***FY 2018 Accomplishments:*** Explore the effectiveness of High Power Microwave (HPM) weapons. Perform detailed modeling and simulation of emerging threats to Naval forces, including developing new tools to better predict the effectiveness of HPM weapons. The outputs from the simulation work will be experimentally verified and utilized to inform future technology investments in solid state HPM technologies for improved capabilities. Detailed size, weight and power trade-off studies of candidate solid state technologies performed to enable conceptual design development. ***FY 2019 Plans:*** Funds will be used towards the isolating/determining high power microwave (HPM) waveform spaces that enable control over desired levels-of-lethality on small unmanned aerial vehicle (sUAV) and similar targets, with the least power density, to drive development of transitionable HPM sources and electronically steerable radiators.	4.828	9.000
Congressional Add: Adaptive Optics ***FY 2018 Accomplishments:*** The Navy is exploring the potential to defeat anti-ship cruise missiles (ASCM) with laser weapons. It is generally believed that adaptive optics will be critical to compensate for atmospheric effects that would otherwise degrade the effectiveness of a laser for this critical mission. The FY18 appropriation will be used to mature technology and scientific understanding that advances the Navy's ability to use adaptive optics in future laser weapons. ***FY 2019 Plans:*** N/A	4.828	0.000
Congressional Add: Directed Energy ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Develop advanced components for use in directed energy applications.	0.000	4.000
Congressional Adds Subtotals	9.656	13.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602114N / *Power Proj Applied Research*	**Project (Number/Name)** 9999 / *Congressional Adds*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other Projects.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602123N *I Force Protection Applied Res*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	182.614	180.549	119.517	-	119.517	119.535	121.947	124.439	126.937	Continuing	Continuing
0000: *Force Protection Applied Res*	0.000	122.743	124.049	119.517	-	119.517	119.535	121.947	124.439	126.937	Continuing	Continuing
9999: *Congressional Adds*	0.000	59.871	56.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	116.371

A. Mission Description and Budget Item Justification

The activities described in this program element (PE) address future Navy and Marine Corps capabilities needed to maintain maritime superiority and ensure national security. They are based on input from Naval Research Enterprise stakeholders (including the Naval enterprises, the combatant commands, OPNAV and Headquarters Marine Corps) and are designed to exploit breakthroughs in science and technology in order to deliver maximum warfighting benefit to our sailors and marines. These efforts are aligned with shared priorities throughout the whole of RDT&E in order to quickly advance new capabilities from discovery to deployment across the warfighting domains.

This PE addresses applied research associated with providing the capability of Platform and Force Protection for the U.S. Navy. It supports the development of technologies associated with all naval platforms (surface, subsurface, terrestrial, and air) and the protection of those platforms. The goal is to provide the ability to win or avoid engagements with other platforms or weapons and, in the event of engagement, to resist and control damage while preserving operational capability. Within the Naval Transformational Roadmap, this investment directly supports the Theater Air and Missile Defense transformational capability required by Sea Shield and the Ship to Objective Maneuver key transformational capability. This is accomplished by improvements in platform offensive performance, stealth, and self-defense.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	125.557	124.049	121.889	-	121.889
Current President's Budget	182.614	180.549	119.517	-	119.517
Total Adjustments	57.057	56.500	-2.372	-	-2.372
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	56.500			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-4.947	0.000			
• Program Adjustments	0.000	0.000	-2.372	-	-2.372
• Rate/Misc Adjustments	0.004	0.000	0.000	-	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy				Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*		R-1 Program Element (Number/Name) PE 0602123N *I Force Protection Applied Res*		
• Congressional Add Adjustments	62.000	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Program Increase*	24.142	0.000
Congressional Add: *Alternative Energy Research*	24.142	28.000
Congressional Add: *Power Generation and Storage Research*	0.000	5.000
Congressional Add: *Battery Storage and Safety*	4.828	0.000
Congressional Add: *Hybrid Composite Structures Research for Enhanced Mobility*	4.828	5.000
Congressional Add: *Standoff Detection of Buried Hazards*	1.931	3.000
Congressional Add: *Advanced Energetics Research*	0.000	7.500
Congressional Add: *Advanced Hull Form Development and Demonstration*	0.000	8.000
Congressional Add Subtotals for Project: 9999	59.871	56.500
Congressional Add Totals for all Projects	59.871	56.500

Change Summary Explanation

The program decrease in FY 2020 is due to the completion of research efforts included in the Applied Research Challenge (ARC) program through FY 2019. These efforts were within Surface Ship & Submarine HM&E subproject.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / *Force Protection Applied Res*	Project (Number/Name) 0000 / *Force Protection Applied Res*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *Force Protection Applied Res*	0.000	122.743	124.049	119.517	-	119.517	119.535	121.947	124.439	126.937	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project addresses applied research associated with providing the capability of Platform and Force Protection for the U.S. Navy. It supports the development of technologies associated with all naval platforms (surface, subsurface, terrestrial, and air) and the protection of those platforms. The goal is to provide the ability to win or avoid engagements with other platforms or weapons and, in the event of engagement, to resist and control damage while preserving operational capability. Within the Naval Transformational Roadmap, this investment directly supports the Theater Air and Missile Defense transformational capability required by Sea Shield and the Ship to Objective Maneuver key transformational capability by virtue of improvements in platform offensive performance, stealth, and self-defense.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: AIRCRAFT TECHNOLOGY	38.127	35.419	35.882	0.000	35.882
Description: The Aircraft Technology activity develops technologies for reduced observables technology and enhanced capability of naval aviation aircraft platforms in terms of mission effectiveness, platform range, responsiveness, survivability, observability, readiness, safety and life cycle cost. It also develops new Naval air vehicle concepts and high impact, saleable naval air vehicle technologies, such as - autonomous air vehicle command and control, helicopter and tilt rotor systems, aerodynamics, propulsion systems, materials, structures and flight controls for future and legacy air vehicles. Variable Cycle Advanced Technology (VCAT) will identify and mature critical, relevant variable/adaptive cycle propulsion system technologies for the next generation carrier-based Tactical Aircraft (TACAIR)/Intelligence, Surveillance and Reconnaissance (ISR) systems. The Sea-Based Aviation National Naval Responsibility (SBA NNR) Structures and Materials program will develop the next generation structural capability and material response science for aircraft technology in fixed and rotary wing, manned and unmanned airframe technology to achieve reduced weight, increased durability, strength, streamlined manufacturability, reduced life-cycle cost and maintenance/readiness gaps improvements. Program payoffs include increased availability/readiness, reduced sustainment requirements, fatigue/loads life enhancement, reduced weight and improved range, and advanced prognostics design tools.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
These efforts addresses unique attributes to propulsion and power technologies for Naval Aviation, as well as those having higher importance to Naval Aviation and some that are more pervasive to all of military aviation. Related basic research efforts are addressed under 0601153N Defense Research Sciences. ***FY 2019 Plans:*** Ongoing research related to SBA NNR priorities in Aviation, Propulsion, and Structures and Materials. Ongoing research in Aircraft Technology, examples of research/efforts include Virtual Ship/Aircraft Dynamic Interface, Manned/Unmanned Handling Qualities and Control, Automated Deck Operations, High Lift Aerodynamics and V/STOL Operations, the development of rotorcraft/VTOL systems automated launch and recovery technology and mechanical/environmental failure prediction research. Ongoing research in Propulsion, examples of research/efforts include the VCAT Program. Major engine manufacturers and system contractors will develop/mature the highest priority, long-lead propulsion system technologies, including variable/adaptive cycle engine components, for next generation carrier-based TACAIR/ ISR systems. Ongoing research in Structures and Materials, examples of research/efforts include advanced composite durability technology, new materials development, process-property relationship analysis, improved material selection tools, structural life prediction, multi-functional surfaces, and structural optimization for lightweighting.. Expanding material degradation risk prediction and operational environment-driven materials selection methods. Ongoing research related to Autonomy, examples of research/efforts include high confidence/Safe Autonomous Control in naval environments and on supervisory control of decentralized heterogeneous UAS. Expand efforts on safe-perception based autonomous control in complex naval environments and on autonomy to support combined unmanned and manned air systems/units. ***FY 2020 Base Plans:*** Conduct ongoing research related to Sea Based Aviation National Naval Responsibility (SBA NNR) priorities in Aviation, Propulsion, and Structures and Materials. Ongoing research in Aircraft Technology, examples of research/efforts include Virtual Ship/Aircraft Dynamic Interface, Manned/Unmanned Handling Qualities and Control, Automated Deck Operations, High Lift Aerodynamics and Vertical/Short Take-off and Landing (V/					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
STOL) Operations, the development of rotorcraft/Vertical Take-Off and Landing (VTOL) systems automated launch and recovery technology and mechanical/ environmental failure prediction research. Examples of ongoing research in Propulsion include the Variable Cycle Advanced Technology (VCAT) Program. Major engine manufacturers and system contractors will develop/mature the highest priority, long-lead propulsion system technologies, including variable/adaptive cycle engine components, for next generation carrier-based Tactical Aircraft (TACAIR) systems. Ongoing research in Structures and Materials include: advanced composite durability technology; new materials development; process-property relationship analysis; improved material selection tools; structural life prediction; multi-functional surfaces; and structural optimization for reducing structural weight. Methods to expanding material degradation risk prediction and operational environment-driven materials selection methods will be created. Examples of ongoing research related to Autonomy include: high confidence/Safe Autonomous Control in naval environments and on supervisory control of decentralized heterogeneous Unmanned Aircraft Systems (UAS). Expand efforts on safe-perception based autonomous control in complex naval environments and on autonomy to support combined unmanned and manned air systems/units. Specific efforts in FY 2020 include: Efforts to mature Integrated Propulsion, Power and Thermal Management System technologies to an appropriate level to meet the next generation TACAIR Technology Maturation Readiness Review notional plan and schedule. Investigate technologies that could increase engine efficiency, power and aircraft range including engine inlet distortion control, turbomachinery and drive systems optimization, high temperature engine materials and coatings, engine compressor casing treatments and advanced thermal management and transport systems. Flight Dynamics & Control analysis and scaled experiments to demonstrate knowledge fundamental aspects of phenomena associated with multibody control systems with a focus on the ability to demonstrate guaranteed performance relative to a desired end state. Demonstrate algorithms and technology to enable precise ship-relative navigation in GPS-denied environments. Aerodynamics research to demonstrate a new method for in situ measurement if ship airwake dynamics. Demonstrate a leap forward in the capability to run real-time simulations of the coupled aerodynamics involved in					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
ship-based recovery of rotary wing aircraft in order to advance the capability of piloted simulations and increase their effectiveness as training tools. High Fidelity Composite Characterization for Rapid Certification of Advanced Structures - application of previously developed advanced characterization methods for current and emerging next generation Composites. This data will feed rapid certification through advanced damage modeling and failure predictions. Advanced Galvanic Compatibly Theory for Operationally Optimized Material Selection - validation and transition of novel compatibility theory to improve material selection and design in vehicle sustainment and life extension. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: FLEET FORCE PROTECTION AND DEFENSE AGAINST UNDERSEA THREATS	3.480	5.775	5.834	0.000	5.834
Description: Fleet Force Protection and Defense against Undersea Threats efforts include applied research for complementary sensor and processing technologies for platform protection. Current small platforms (both surface and airborne) have little to no situational awareness (SA) or self-protection against air, surface, and asymmetric threats. A goal of this activity is to provide these platforms with effective self-protection. The technology areas specific to platform protection will develop individual, multispectral electro-optical (EO), infrared (IR), radio frequency (RF), electro-magnetic (EM), visual and acoustic or chemical sensors/ biosensors and associated processing. To defend platforms from current and advanced threats in at-sea littoral environments and in port, these technologies must improve multispectral detection and distribution of specific threat information. ***FY 2019 Plans:*** Undersea Warfare: Ongoing research in Undersea Warfare, examples of research include conceptualizing and performing laboratory and field studies to: developing acoustics technology and associated signal processing for the detection of small unmanned aerial vehicles (UAVs); continued development of a pressure tolerant, inexpensive hydrogen storage based on hydrogenated graphene to increase undersea storage capacity. Materials and Chemistry:					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Ongoing research in Materials and Chemistry, examples of research include design and development, utilizing room temperature ionic liquids, to demonstrate and fabricate inexpensive, miniaturized, low power electrochemical sensors for use in autonomous as well as distributed sensor networks; developing real time, standoff, moving target, laser based detection for explosives and hazardous chemicals with the intent of shifting the paradigm of trace chemical detection through surface contact swabbing to a faster, more flexible wide area, standoff method for significant enhancement of force protection; development and design of a new class of safe high performance rechargeable zinc air batteries to supplant state of lithium-ion batteries; development of chemical vapor sensing strategy for application in a marine environment, significantly different than terrestrial environment; performance demonstrations of highly sensitive electrochemical detection elements incorporated into electronic integrated circuits; and demonstrations of high efficiency of zinc sponge anode in an electrochemical cell.					
FY 2020 Base Plans: Sensors and Associated Processing: Develop a new 3D ISAR capability for moving targets in air, space, ground, and sea to allow better target recognition. Materials and Chemistry: Design and develop, utilizing room temperature ionic liquids, to demonstrate and fabricate inexpensive, miniaturized, low power electrochemical sensors for use in autonomous as well as distributed sensor networks. Develop real time, standoff, moving target, laser based detection for explosives and hazardous chemicals with the intent of shifting the paradigm of trace chemical detection through surface contact swabbing to a faster, more flexible wide area, standoff method for significant enhancement of force protection. Develop and design a new class of safe high performance rechargeable zinc air batteries to supplant state of lithium-ion batteries. Development of chemical vapor sensing strategy for application in marine environment, significantly different than terrestrial environment. Significant accomplishments include performance demonstration of highly sensitive electrochemical detection elements incorporated into electronic integrated circuits. Demonstration of high efficiency of zinc sponge anode in an electrochemical cell. Undersea Warfare: Conceptualize and perform laboratory and field studies to: develop acoustics technology and associated signal processing for the detection of small Unmanned Aerial Vehicles (UAVs); and the development of a pressure tolerant, inexpensive hydrogen storage based on hydrogenated graphene to increase undersea storage capacity.					
FY 2020 OCO Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: ADVANCED ENERGETICS	5.014	5.497	5.380	0.000	5.380
Description: Advanced Energetics efforts address technology development to provide substantial improvements in energetic material systems and subsystems, primarily in terms of performance, but also addressing safety, reliability, and affordability concerns. Goals include: advanced energetic materials for warheads, propellants, and reactive material based subsystems for both defensive and offensive applications. Efforts include: development of new fuels, oxidizers, explosive ingredients and formulations; and reliable simulation tools and diagnostics to develop and design superior-performance, and/or reduced-vulnerability systems tailored to specific warfighter missions. ***FY 2019 Plans:*** Ongoing research related to Advanced Energetics including development and evaluation of advanced explosive/ propellant/reactive ingredients and formulations for the next generation higher performing systems. Ongoing research in proof of concept efforts to develop insensitive explosives, propellants, and munitions without compromising performance. This work involves development of high quality, small particle energetic ingredients, novel processing techniques, and advanced energy conversion concepts; and involves both theoretical and experimental efforts. Ongoing research focused on chemical processing technologies. Incorporate molecular design and crystal morphology technology into scale-up and process development. New compliant commodity energetic ingredients will be transitioned to the industrial base as appropriate. Continue research in development and diagnostics of novel energy conversion concepts to enhance performance, more efficiently exploit available energy, and more effectively couple energy to target for air, surface, and underwater warhead application. ***FY 2020 Base Plans:*** Conduct research related to Advanced Energetics including development and evaluation of advanced explosive/ propellant/					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
reactive ingredients and formulations for the next generation higher performing systems. Conduct research in proof of concept efforts to develop insensitive explosives, propellants, and munitions without compromising performance. This work involves development of high quality, small particle energetic ingredients, novel processing techniques, and advanced energy conversion concepts; and involves both theoretical and experimental efforts. Conduct research focused on chemical processing technologies. Incorporate molecular design and crystal morphology technology into scale-up and process development. New compliant commodity energetic ingredients will be transitioned to the industrial base as appropriate. Conduct research in development and diagnostics of novel energy conversion concepts to enhance performance, more efficiently exploit available energy, and more effectively couple energy to target for air, surface, and underwater warhead application. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: SURFACE SHIP & SUBMARINE HULL MECHANICAL & ELECTRICAL (HM&E)	71.587	72.772	67.859	0.000	67.859
Description: Technology programs focused on providing technologically superior warfighting capabilities at reduced total ownership costs for surface and subsurface platforms through investments in applied research and advanced technology development of programs in: a) Advanced Naval Power, b) hydrodynamics, c) structures, d) autonomy for unmanned surface vehicles (USV), and e) platform survivability. This element also includes the National Naval Responsibility in Naval Engineering (NNR-NE). The NNR-NE supports early applied research in the areas of propulsion, platform structures, hydrodynamics, automation control and system engineering,					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
design tools, naval power systems and ensuring a strong and healthy academic infrastructure. Specific research themes are: Advanced Naval Power Systems Technology: Efforts address electrical and auxiliary system and component technology to dramatically improve energy and power density, operating efficiency, and recoverability from casualties. A major investment focus is providing the power and energy required for directed energy weapons on current and future surface combatants. Advanced Naval Power efforts include: developing technologies for high-power, cyber-secured energy networks, distribution and control of power, providing warfighting capability with more energy efficient systems; mitigate adverse impacts of alternative fuel on Naval platforms and equipment; and utilizing the Electric Ship Research and Development Consortium (ESRDC) efforts to develop modeling and simulation tools to provide critical design and operational capabilities for the all-electric ship program, accelerate development and demonstration of technologies, reduce risk of new technology insertion, and address the national shortage of electrical power engineers. Develop new machinery integration concepts. Develop simulation based Verification, Validation and Accreditation (VV&A) methods and technologies. Contribute to system reconfiguration. Design a ship electrical system architecture based on a main bus that distributes "rough" Direct Current (DC) power throughout the ship at nominally 10 KV. Development of macro- and atomic-scale multi-physics models is being pursued to enhance understanding of materials processing and performance, energy conversion mechanisms, cyber-physical energy concepts, and power management. System-level studies focus on the scalability and reliability of component technologies. Another thrust is the development of tools to model heat transfer at multiple length scales allowing for simulation of heat flow through the ship in order to evaluate the impact of power conversion electronics, sensors, and weapons on the overall thermal balance of the vessel. Advanced Sea Platform Technology: Hydrodynamics: Critical platform design for surface ships hydrodynamics that is focused on the theory, computation, and lab and at-sea experimentation to develop understanding and prediction capabilities for all hydrodynamic phenomena associated with surface ships and small craft, their effects on vessel performance, and concepts for modification. Propulsor hydrodynamics is focused on understanding the physics of flow around propulsors and their interactions to improve propulsor performance, mobility, efficiency, and affordability, as well as prediction and control of various types of cavitation on propulsors and appendages. This also includes predictive capability of cavitation inception, thrust breakdown, and erosion phenomenon and scaling					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
laws. Technology efforts in the area of Subsurface Hydrodynamics include identifying, understanding, predicting, and controlling flow physics, as well as turbulence and stratified wakes. This is further applied to Subsurface Maneuvering Technologies, and understanding the Dynamics of Interacting Platforms. Additionally hydrodynamic technologies focused on the signature aspects of the hull-propulsor interaction and maneuvering. Platform Structures: Focused on time-varying, structural reliability analysis and prediction for a ship structural system with uncertainty quantification and propagation. Specific topics include novel structural configurations across composite and metallic materials and prediction methods for advanced global hull strength, local panel and component strength, fatigue and fracture strength, and seaway loads and load effects for high-speed/high-performance ships and vessels. Hull life assurance addresses development of new structural system approaches for surface ships and submarines, including the management of weapons effects to control structural damage and the improvement of structural materials. Unmanned Surface Vehicles (USV): Autonomy for USVs and related mission functions aligned with Naval S&T strategic focus on autonomy and unmanned vehicles. Unmanned Sea Surface Vehicle (USSV) applied research includes short-term motion forecasting for recovery of USSVs on a host ship in higher sea states and determination of slamming loads on high-speed planing hulls for structural weight reduction Distributed intelligence for automated survivability addresses both the basic technology of automating machinery control systems, as well as, distributed control of systems utilizing autonomy for mission context based reconfiguration. Sea Platform Survivability Technology: Aligned with survivability S&T strategic focus area, research investigates electromagnetic (EM) sources (including major ferro and non-ferromagnetic sources, eddy currents, and Corrosion Related Magnetic Fields (CRM)) that are associated with naval platforms. Develop understanding of EM field propagation relationships and analysis aids, and technologies to predict the electromagnetic properties of a naval platform. Advance physics based understanding of platform acoustics. Discover and develop algorithms and methods that will enable the development of improved design, analysis, and prediction tools for enhanced acoustic performance. Understand, design and develop optical and acoustic metamaterials to control light and sound propagation over a large frequency range. New architectures to overcome challenges associated with loss, bandwidth, and scalability are being explored. Design and develop models, algorithms, and integrated development environments for simulation and control of complex, interdependent, distributed shipboard machinery systems to enable integrated, autonomous operation and reconfiguration of shipboard machinery systems. Efforts also include: signature reduction, hull life assurance, hydromechanics, distributed control for automated survivability					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
(includes damage control), and advanced naval power systems. Signature reduction addresses electromagnetic, infrared, structural acoustics and acoustic signature tailoring, both topside and underwater. Develop and advance time critical stealth technologies for SSBN and SSN programs. ***FY 2019 Plans:*** Advanced Energy Systems Research: Ongoing applied research related to critical S&T in Power & Energy Technology related to energy systems. This research in energy systems provides innovative energy technologies and system designs to increase mission capability. Areas of research include all scientific and engineering aspects of the production, conversion, delivery, and use of energy for installation critical infrastructure, forward operating and remote bases, humanitarian assistance and disaster relief operations, manned and unmanned platforms, and general energy network applications. Primary objectives are to improve warfighting readiness, effectiveness, and flexibility through research projects focused on enhancing energy cyber-security, resiliency and efficiency. Research programs often include activities that purposely incorporate veterans and other military personnel into projects to enhance military applicability and to provide a sustainable source of military-experienced professionals for the DoN energy workforce. Advanced Naval Power Systems Technology: Ongoing research related to the NGIPS and Distribution/Control of Power Advanced Power Systems with a focus on power and energy requirements for directed energy weapons on current and future surface combatants. Advanced Sea Platform Technology: Ongoing applied research related to critical S&T to investigate platform design efforts related to propulsor and subsurface hydrodynamics; structural reliability science; and structural acoustics. Expand research related to the unmanned sea surface vehicle. Ongoing research related to naval engineering and platform design, including Ohio Replacement Program efforts. Sea Platform Survivability Technology: Ongoing applied research related to critical S&T to investigate efforts related to signature reduction; machinery autonomy; and platform survivability.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Science & Technology to Address Complex Hybrid Warfare Threats: Ongoing projects to counter complex hybrid warfare threats. S&T technologies will address a broad range of multi-faceted threats that employ both conventional and unconventional forces. The S&T technologies will continue to expand and emphasize various compact platforms in multi-environments. Applied Research Challenge (ARC): Ongoing base program efforts, initiated in FY 2017 and FY 2018, including network information sciences, long-range high-resolution imaging, ocean surface scatter in RF propagation, wake measurement technologies, thermal management systems, high power control modules for ship application, decision support/uncertainty analysis for operational environments, and reactive composite materials. In particular, continue research to develop and test autonomy for Unmanned Undersea Vehicle (UUV) missions including understanding of counter-UUV autonomy options; implementations and testing. Materials and Chemistry: Ongoing research for understanding methods for fabricating nickel/graphene/cobalt magnetic tunneling junctions to develop new tunnel barrier materials technology for fast low power radiation hardened memory and magnetic sensors. This continuing effort will be a fundamental shift for magnetic tunnel junction technology, which is significantly different than the use of conventional oxides such as MgO and Al2O3. Favorable accomplishments have been made to show that graphene can be used as a tunnel barrier material. Electronics: Ongoing research to create and explore new high voltage, high efficiency wide bandgap and ultra-wide bandgap power switches for electric propulsion and electric weapons. ***FY 2020 Base Plans:*** Advanced Naval Power and Energy Systems Research and Technology: Advanced energy systems research includes a significant research program with the Hawaii Natural Energy Institute (HNEI) at the University of Hawaii that is focused on the analysis and optimization of resilient electrical grids and microgrids in the Pacific region. Prior and on-going research has demonstrated the ability of advanced batteries and other power management technologies to greatly enhance the stability and reliability of electrical grids possessing high penetrations of variable renewable energy resources. Results from these demonstrations					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
will be used to evaluate and increase the energy resiliency of critically infrastructures on DOD installations in the Pacific. The HNEI program has also initiated a new collaboration with the Alaska Center for Energy and Power (ACEP) at the University of Alaska Fairbanks to explore the use of energy storage technologies and distributed energy resources to enhance the energy resiliency of microgrids at remote locations and at DOD facilities in cold weather environments. To support both new and existing surface ship and submarine programs, specific new and ongoing efforts are aimed at supporting electrical system reliability, as well as advanced power distribution and control and will utilize the Electric Ship Research and Development Consortium (ESRDC) to develop modeling and simulation tools, system analysis tools and models to provide critical design and operational capabilities for the all-electric ship program, accelerate development and demonstration of technologies, and to reduce risk of technology insertion. These efforts also address the national shortage of naval electrical power engineers. Ongoing research related to the Next Generation Integrated Power System (NGIPS) and Distribution/Control of Power Advanced Power Systems with a focus on power and energy requirements for directed energy weapons and advance sensor systems on current and future surface combatants, as well as for unmanned naval platforms. Advanced Sea Platform Technology: New and ongoing applied research related to critical S&T that supports platform design and advanced capability efforts related to propulsor, surface, and subsurface hydrodynamics; platform performance, and platform structural reliability. Specifically, efforts to utilize advanced analytics (machine learning and artificial intelligence), incorporate environmental effects on platform performance, research related to advancing unmanned sea surface vessel technologies and capabilities. Specific naval engineering and platform design efforts to support set-based design for the Next Generation Attack Submarine SSN(X), and efforts to mitigate technology and susceptibility risk for the COLUMBIA class submarine program and the Future Surface Combatant Force. Sea Platform Survivability Technology: New and ongoing applied research related to critical S&T to investigate efforts related to signature reduction; structural and machinery acoustics; machinery autonomy; and platform survivability (detectability and susceptibility); and acoustic and non-acoustic signatures. Specifically, efforts utilizing advanced analytics (machine learning and artificial intelligence) and the integration of environmental effects on platform performance and detectability, Specific naval engineering and platform design efforts to support the Next Generation Attack					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Submarine SSN(X), and efforts to mitigate technology and susceptibility risk for the COLUMBIA class submarine program and the Future Surface Combatant Force. Ongoing base program efforts, initiated in FY 2018 and FY 2019, include ocean surface scatter in RF propagation, wake measurement technologies, thermal management systems, high power control modules for ship application, decision support/uncertainty analysis in operational environments, and reactive composite materials. Submarine Security S&T New and ongoing research efforts focused on the science and physics based signal detection technologies that, individually or as a system, can impact the security of the SSBN and submarines in general. Efforts looking at both passive and active detection technologies with near term (0-5 years), mid-term (5-10 years) and far term (10-20 years) implications, as well as improving the understanding of the generation, radiation, propagation, scatter, and detection of a variety of signal types (acoustic, chemical, optical, electromagnetic, hydrodynamic and radiological) associated with a submarine's operation. Autonomy Technology: Ongoing research related to critical multidisciplinary autonomy challenges that cut across areas/domains, including air, sea, undersea and ground. This includes multi-disciplinary research into the science of autonomy focuses on four interrelated areas: scalable and robust distributed collaboration among autonomous systems; human/unmanned system collaboration; autonomous perception and intelligent decision-making; and intelligent architectures for autonomous systems. Continue research to develop and test autonomy for Medium Displacement Unmanned Surface Vehicle (MDUSV) missions including perception and classification. Ongoing efforts, initiated in FY 2018 and FY 2019, include network information sciences, long-range high-resolution imaging, and decision support/uncertainty analysis for operational environments. In particular, continue research to develop and test autonomy for Unmanned Undersea Vehicle (UUV) missions including understanding of counter-UUV autonomy options; implementations and testing. Autonomy development involving a shared world model and sensor feedback will continue. Extensive in-water testing will continue. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:***					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
The funding decrease is due to the completion of the Applied Research Challenge (ARC) program which concludes in FY19.					
Title: NAVAL RESEARCH ENTERPRISE	4.535	4.586	4.562	0.000	4.562
Description: The Independent Applied Research (IAR) R2 activity was stood up in FY 2013 as the Naval Research Enterprise (NRE) to consolidate all NRE related IAR investments. Projects funded in this R2 Activity are intended to be approximately 2-3 years in length. Based on historical trends approximately 30% of these projects will turn over each year. The Naval Research Enterprise (NRE) encompasses the IAR efforts focused on solving a wide range of Naval Science and Technology (S&T) fleet issues utilizing unique Naval Warfare Center (WC) laboratory capabilities. Efforts under this activity address the full spectrum of the Naval Research and Development Framework using focus areas which engage Naval aviation, sea surface, undersea, space, weapons, communication, information, and human systems. The IAR Program provides participating WCs with in-house funding for applied research to support the execution of their assigned missions by: -Developing and maintaining a cadre of active researchers who can distill and extend results from worldwide research and apply them to solve Naval problems. -Promoting the hiring and development of talented new scientists and engineers (S&E) with the insurance of proper mentoring with senior personnel. -Encouraging collaboration with universities, private industry, and other Navy and Department of Defense laboratories. Funded projects are chosen through rigorous internal competition by each WC's selection committee and typically last two to three years. IAR projects are generally designed to promote investment in high-risk/high-payoff research and also allow young S&Es to manage Navy relevant research projects. A limited number of successful efforts developed under the In-House Laboratory Independent Research (ILIR) basic research Program Element 0601152N are matured and further developed under the IAR program with the goal of transitioning these technologies to the warfighter. ***FY 2019 Plans:*** Independent Applied Research (IAR) shall align with Naval Research framework priorities (IAR projects which were three years in duration); Augmented Warfighter, Integrated & Distributed Forces; Operational Endurance, Sensing and Sense-Making, and Scalable Lethality. FY19 IAR projects will expand efforts in the areas of physics, chemistry, biotechnology, earth sciences, mathematics, and other hard and soft sciences. Representative projects include; Life Preserver Performance in Waves, Electronic Warfare Activity					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Recognition, Boron-Based Solid Fuel Development for Ramjet Application, Modularization Algorithm for Additive Manufactured Parts, Data Visualization Support for Creation of a Numerical Table: Effects on Training and Performance, Development of a Fully Integrated Ignition System for Multiple Pulse Hybrid Rocket Motor Firings, Active Sonar-based Cooperative UUV Interception, HFA Tactical Oceanography, and Ultra Short Pulse Laser Induced Plasma Filaments for Extended Covert Communications. ***FY 2020 Base Plans:*** Independent Applied Research (IAR) shall align with Naval Research framework priorities (IAR projects which were three years in duration); Augmented Warfighter, Integrated & Distributed Forces; Operational Endurance, Sensing and Sense-Making, and Scalable Lethality. FY20 IAR projects will expand efforts in the areas of physics, chemistry, biotechnology, earth sciences, mathematics, and other hard and soft sciences. Representative projects include; Life Preserver Performance in Waves, Electronic Warfare Activity Recognition, Boron-Based Solid Fuel Development for Ramjet Application, Modularization Algorithm for Additive Manufactured Parts, Data Visualization Support for Creation of a Numerical Table: Effects on Training and Performance, Development of a Fully Integrated Ignition System for Multiple Pulse Hybrid Rocket Motor Firings, Active Sonar-based Cooperative Unmanned Underwater Vehicle Interception, and Ultra Short Pulse Laser Induced Plasma Filaments for Extended Covert Communications. Fund the development of innovative prototypes at Warfare Centers and Naval Laboratories solving key warfighter problems that are identified through the Hacking for Defense innovation process pipeline. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Accomplishments/Planned Programs Subtotals	122.743	124.049	119.517	0.000	119.517

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

E. Performance Metrics

This PE supports the development of technologies associated with all naval platforms (surface, subsurface, terrestrial and air) and the protection of those platforms. Each PE Activity has unique goals and metrics, some of which include classified quantitative measurements. Overall metric goals are focused on achieving sufficient improvement in component or system capability such that the 6.2 applied research projects meet the need of or produce a demand for inclusion in advanced technology that may lead to incorporation into acquisition programs or industry products available to acquisition programs. Efforts funded in this PE also include energy programs in support of Navy energy guidance and efforts in support of the Ohio Replacement program.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / *Force Protection Applied Res*	Project (Number/Name) 9999 / *Congressional Adds*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	59.871	56.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	116.371

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Program Increase ***FY 2018 Accomplishments:*** Funding used to advance research and facilitate technology adoption for lithium-ion battery safety and electrical grid resiliency, reliability and security. ***FY 2019 Plans:*** N/A	24.142	0.000
Congressional Add: Alternative Energy Research ***FY 2018 Accomplishments:*** Funding used to carryout alternative energy research in several areas including modeling and simulation tools for energy efficient ship design, unmanned vehicle power systems, cyber-secure and resilient micro-grids, marine-derived renewable energy, and a variety of shore-based energy efforts addressing energy challenges in the Asia-Pacific regions, including Hawaii, Alaska, Guam, California, and Australia. ***FY 2019 Plans:*** Funding used to carryout alternative energy research in several areas including modeling and simulation tools for energy efficient ship design, unmanned vehicle power systems, cyber-secure and resilient micro-grids, marine-derived renewable energy, and a variety of shore-based energy efforts addressing energy challenges in the Asia-Pacific regions, including Hawaii, Alaska, Guam, California, and Australia.	24.142	28.000
Congressional Add: Power Generation and Storage Research ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Conduct and expand on-going competitively awarded efforts that improve Li-ion battery safety and increase micro-grid resiliency and efficiency	0.000	5.000
Congressional Add: Battery Storage and Safety ***FY 2018 Accomplishments:*** Funding used to conduct effort to develop safer battery technologies, including nonflammable electrolytes and safe cell technology, and to increase micro-grid resiliency and efficiency,	4.828	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 9999 / *Congressional Adds*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
including advancements in battery technologies and utilization. Conduct and expand on-going competitively awarded efforts that improve Li-ion battery safety and increase micro-grid resiliency and efficiency. ***FY 2019 Plans:*** N/A		
Congressional Add: Hybrid Composite Structures Research for Enhanced Mobility ***FY 2018 Accomplishments:*** This effort will develop advanced fiber reinforced plastics for maritime craft and vessel structural components having the strength and weight benefits of traditional composite materials but without the corresponding cost and producibility limitations. In addition, this effort will develop hybrid inflatable structures for high load applications culminating in building and testing a full-scale lightweight ramp structure capable of supporting a 75 ton M1A1 tank. This ramp concept combines a metallic or composite compression member, drop stitch panels, and tension cables to form a lightweight, foldable ramp compatible with smaller vessels such as the Expeditionary Fast Transport and amphibious craft concepts such as the Ultra-Heavy Amphibious Connector. ***FY 2019 Plans:*** This effort will develop advanced fiber reinforced plastics for maritime craft and vessel structural components having the strength and weight benefits of traditional composite materials but without the corresponding cost and producibility limitations. In addition, this effort will develop hybrid inflatable structures for high load applications culminating in building and testing a full-scale lightweight ramp structure capable of supporting a 75 ton M1A1 tank. This ramp concept combines a metallic or composite compression member, drop stitch panels, and tension cables to form a lightweight, foldable ramp compatible with smaller vessels such as the Expeditionary Fast Transport and amphibious craft concepts such as the Ultra-Heavy Amphibious Connector.	4.828	5.000
Congressional Add: Standoff Detection of Buried Hazards ***FY 2018 Accomplishments:*** Detection of Buried Hazards : Develop the basic signal processing requirements for the Laser Multi-Beam Differential Interferometric Sensor system have been analyzed and transformed into system specifications. Draft the necessary test plan to investigate the effectiveness based both acoustic and seismic excitation for buried object detection in outdoor environment ***FY 2019 Plans:*** Detection of Buried Hazards : Develop the basic signal processing requirements for the Laser Multi-Beam Differential Interferometric Sensor system have been analyzed and transformed into system specifications. Draft the necessary test plan to investigate the effectiveness based both acoustic and seismic excitation for buried object detection in outdoor environment	1.931	3.000
Congressional Add: Advanced Energetics Research	0.000	7.500

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 9999 / *Congressional Adds*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
FY 2018 Accomplishments: N/A ***FY 2019 Plans:*** These funds will be used towards the advanced demonstration of energetic materials in a variety of weapon system applications to include: high performance solid rocket and air breathing propulsion, reactive materials demonstrations and effects in advanced lethality and effectiveness models, advanced warhead concepts to include novel reactive shaped charge configurations, hybrid reactive material warhead demonstrations, and the development and demonstration of any necessary modeling and simulation capabilities for quantification of damage effects on adversary weapon systems, and other potential energetic technologies.		
Congressional Add: Advanced Hull Form Development and Demonstration ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Using computation fluid dynamic modeling, design innovative sea-keeping small-craft with improved performance characteristics utilizing advanced building techniques and materials.	0.000	8.000
Congressional Adds Subtotals	59.871	56.500

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not applicable.

E. Performance Metrics

Congressional Interest Items not included in other Projects.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602131M *I Marine Corps Lndg Force Tech*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	54.526	63.212	56.604	-	56.604	50.623	51.624	52.674	53.728	Continuing	Continuing
2958: *Cyberspace Activities*	0.000	0.000	0.000	6.273	-	6.273	5.877	6.005	6.125	6.248	Continuing	Continuing
3001: *Marine Corps Landing Force Tech*	0.000	52.595	56.212	50.331	-	50.331	44.746	45.619	46.549	47.480	Continuing	Continuing
9999: *Congressional Adds*	0.000	1.931	7.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	8.931

A. Mission Description and Budget Item Justification

This Program Element (PE) addresses demand signals emphasized by the Commandant of the Marine Corps, the Chief of Naval Operations, and the Chief of Naval Research, as well as those pulled from dynamic engagement with stakeholders. Research efforts are carefully selected to ensure they have the potential to expand warfighting capabilities, inform operational concepts and requirements development, and advance state of the art technology and scientific knowledge. Current guidance also highlights the need to accelerate our pace of development and guide the approach to rapid experimentation, prototyping, and learning.

As reflected in the Marine Corps Operating Concept, the current strategic guidance from the Commandant, Expeditionary Forces will conduct maneuver warfare in environments characterized by complex terrain, technology proliferation, information used as a weapon, a battle of signatures, and an increasingly contested maritime domain. Additionally, an emergent operation stressor is the contested urban environment which exemplifies the characterizations listed above. The urban environment is one of the most complex terrains with physical compartmentalization and canalization, additional physical dimensions (subterranean and multi-story structures), crowded conditions and associated threat obscuration, communications challenges, informational and human aspects, and proliferation of observation and fires technologies. This environment requires capabilities addressing all the activities within this PE and while it provides many challenges, unique opportunities are also presented and can further shape technology approaches.

These future challenges and portents demand robust technologies for the Marine Corps, but the technology options are constrained. They must have a lightweight deployable character, and the ability to operate in austere conditions with little fixed infrastructure or support while retaining the agility and lethality of an integrated maneuver force. Technology must provide full spectrum capability against robust and complex peer and near-peer adversaries while meeting Size, Weight, Power, Post limitations, and information availability within Distributed, Intermittent and Limited environments.

The approach within this PE encompasses ideas that support both revolutionary and evolutionary capabilities, and in this way considers and balances both "push" and "pull" aspects of technology projects. Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602131M *I Marine Corps Lndg Force Tech*

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	53.936	59.607	56.604	-	56.604
Current President's Budget	54.526	63.212	56.604	-	56.604
Total Adjustments	0.590	3.605	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-3.395			
• Congressional Rescissions	-	-			
• Congressional Adds	-	7.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.409	0.000			
• Program Adjustments	0.000	0.000	0.000	-	0.000
• Rate/Misc Adjustments	-0.001	0.000	0.000	-	0.000
• Congressional Add Adjustments	2.000	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Program Increase*	1.931	0.000
Congressional Add: *Interdisciplinary Expeditionary Cybersecurity Research*	0.000	5.000
Congressional Add: *Marine Corps Asset Life-Cycle Management*	0.000	2.000
Congressional Add Subtotals for Project: 9999	1.931	7.000
Congressional Add Totals for all Projects	1.931	7.000

Change Summary Explanation

Cyber Pure Line Item redistribution realigned $6.273M from Project 3001 into Project 2958.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602131M / *Marine Corps Lndg Force Tech*	Project (Number/Name) 2958 / *Cyberspace Activities*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
2958: *Cyberspace Activities*	0.000	0.000	0.000	6.273	-	6.273	5.877	6.005	6.125	6.248	Continuing	Continuing

Note

The plans and associated programs contained in this Project are realigned from the Expeditionary CYBER Project 3001 in PE: 0602131M MARINE CORPS LNDG FORCE TECH beginning in FY 2020.

A. Mission Description and Budget Item Justification

This Project activity provides freedom of maneuver and influence in the cyber-electronic warfare domain while simultaneously denying the same to the adversary and protecting critical command systems. Technologies are being developed using a multi-disciplinary approach that combines Radio Frequency electronics, digital signal processing, computer engineering, software engineering, machine learning and data science to support Naval Expeditionary warfighters operating with size, weight and power constrained equipment in Disrupted, Intermittent, Limited environments. Areas of applied research include distributed precision time, predictive software defined radio architectures, coordinated Cyber and Spectrum maneuver to mitigate detection and exploitation, tactical Cyber visualization, discovering and mapping networks in dense urban environments, contextual awareness and blind channel characterization.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: Expeditionary Cyber	0.000	0.000	6.273	0.000	6.273
Description: This activity provides freedom of maneuver and influence in the cyber-electronic warfare domain while simultaneously denying the same to the adversary and protecting critical command systems. Technologies are being developed using a multi-disciplinary approach that combines Radio Frequency electronics, digital signal processing, computer engineering, software engineering, machine learning and data science to support Naval Expeditionary warfighters operating with size, weight and power constrained equipment in Disrupted, Intermittent, Limited environments. Areas of applied research include distributed precision time, predictive software defined radio architectures, coordinated Cyber and Spectrum maneuver to mitigate detection and exploitation, tactical Cyber visualization, discovering and mapping networks in dense urban environments, contextual awareness and blind channel characterization.					
FY 2019 Plans: N/A					
FY 2020 Base Plans: Cyber related research will be conducted to develop methodologies to securely transfer information real-time across security boundaries for tactical users. Research will expand upon general cyber health assessments for					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602131M / *Marine Corps Lndg Force Tech*	**Project (Number/Name)** 2958 / *Cyberspace Activities*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
distributed systems to understand cyber resilience for systems-of-systems. Develop new algorithms and tools to demonstrate Cyber-EW capabilities for tactical engagement. Cyber-related approaches will be used to better characterize digital waveforms for better situational awareness. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase in FY 2020 is due to realignment of Expeditionary Cyber from the Expeditionary Cyber R-2 Activity in Project 3001 and placed into Project 2958 beginning in FY 2020.					
Accomplishments/Planned Programs Subtotals	0.000	0.000	6.273	0.000	6.273

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

The primary objective of this Project is the development, demonstration, and assessment of technologies that represent capabilities to meet unique Marine Corps needs in conducting Expeditionary Cyber Warfare in the future. The program consists of a collection of projects categorized by critical warfighting function. Individual project metrics reflect the technical goals of each specific project. Typical metrics include the advancement of related Technology Readiness Levels, the degree to which project investments are leveraged with other performers, reduction in life cycle cost upon application of the technology, and the identification of opportunities to transition technology to higher categories of development.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602131M / *Marine Corps Lndg Force Tech*				Project (Number/Name) 3001 / *Marine Corps Landing Force Tech*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
3001: *Marine Corps Landing Force Tech*	0.000	52.595	56.212	50.331	-	50.331	44.746	45.619	46.549	47.480	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project funds applied research; technology assessment, road mapping, and concept development; and less technologically mature projects within the Future Naval Capability (FNC) process as means to inform, enhance, enable, and invent future concepts and capabilities with new Science and Technology (S&T). This project is organized into ten activities, the core of which is represented by the eight Expeditionary Warfighting Capability Areas.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: COMMAND, CONTROL, COMMUNICATIONS, AND COMPUTERS (C4)	4.219	4.430	4.750	0.000	4.750
Description: This activity investigates robust, resilient, and secure networked communications pathways and capability that support an expeditionary force's distributed and disaggregated operations. Research supports both networked and local computation for communications that exploits the expeditionary forces close physical proximity to threats while mitigating shortfalls commiserate within Distributed, Intermittent and Limited environments. Expeditionary forces must operate in the cyber domain and in addition to defending communications networks, vehicles, and weapons systems, are reliant on electronic controllers for basic operations and as such are susceptible to cyber attacks. Technologies addressed within this activity include secure, robust, self-forming, mobile communications networks; distributed computing to support information dissemination to all echelons; improved capabilities in over-the-horizon, beyond line-of-sight, and restricted environment communications and sensors; and software and data processing to support formation of an appropriate common picture. Other efforts include power management, low detectability, conforming to Size, Weight, Power, Cost constraints, and interoperability within the joint environment. ***FY 2019 Plans:*** Understanding the lightweight, deployable character of expeditionary forces, efforts are focusing on the improving and expanding the operational capability of Command, Control, Communications and Computers which requires rethinking many of the underlying technologies. Investigations include increasing bandwidth and dynamic range in portable systems. Also included are electromagnetic signature management, countermeasure and interoperability technologies to manage control and exploitation of the electromagnetic spectrum. Focus is					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602131M / *Marine Corps Lndg Force Tech*	**Project (Number/Name)** 3001 / *Marine Corps Landing Force Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
also on developing underlying technologies to enable multifunction operations at multiple-domain cryptography and security levels. ***FY 2020 Base Plans:*** The Command, Control, Communications and Computers (C4) research focuses on operations in the challenging warfighter electromagnetic spectrum environment by making investments in the multifunction electronic warfare domains. Mission requirements include lightweight, portable, deployable systems for expeditionary forces. Investigations include increasing bandwidth and dynamic range in portable systems. Also included are electromagnetic signature management, machine learning, countermeasures and interoperability technologies to manage control and exploitation of the electromagnetic spectrum. Focus also includes developing underlying technologies to enable multifunction operations at multiple-domain cryptography and security levels. Research is closely coordinated with the Intelligence, Surveillance, and Reconnaissance and Expeditionary Cyber research to address the multifunction requirement of future systems. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: FIREPOWER	6.131	8.190	7.595	0.000	7.595
Description: The activity investigates a large variety of weapons to provide the warfighter with a decisive, yet surgical, tactical advantage to collectively address 21st-century combined-arms warfare against peer and near-peer states. Research efforts increase the reach, lethality and capacity, while retaining mobility and tempo beneficial to expeditionary maneuver warfare. Maintaining focus on size, weight, power, cost Size, Weight, Power, Cost and Distributed, Intermittent and Limited environments stresses the technical solutions available. Technologies being developed are intended for application on both current and future expeditionary weapons and elements of the kill chain. They include, but are not limited to, the following: fuze, fire control, launch/ propulsion, lethality, and accuracy. ***FY 2019 Plans:*** This activity will continue research of end-to-end navigation technologies suitable for flight corrections of gun launched munitions in satellite and network denied environments. Development of real-time, multi-spectral target detection and identification systems continue for individual shooters, providing anomaly and object					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602131M / *Marine Corps Lndg Force Tech*	**Project (Number/Name)** 3001 / *Marine Corps Landing Force Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
detection and decision-aid algorithms. Materials research focuses on thin film coatings that change how munitions interact with electromagnetic waves, and on novel materials and processes to improve energetic output of explosives. Munitions efforts will focus on increasing range and precision at low cost. ***FY 2020 Base Plans:*** Resources in this activity will be used to conduct research in end-to-end navigation technologies suitable for shaping the trajectories of extended range, precision, gun-launched munitions in satellite- and network-denied environments. Conduct research into real-time, multi-spectral target detection and identification technologies for individual shooters will continue in order to improve anomaly and object detection and decision-aid algorithms. Conduct research to develop thin film coatings that will change how munitions interact with electromagnetic waves, and for novel materials and processes to improve energetic output of explosives. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: FORCE PROTECTION ***Description:*** This activity investigates new ways and means to protect forces and materiel across all operational settings, from contested sea-land surface interfaces to complex urban environments. The portfolio protects against adversaries' challenges such as guided-rockets and missiles, mobile coastal artillery, threat Electronic Warfare, and counter Intelligence, Surveillance and Reconnaissance. Mines and obstacles both in the water and ashore also complicate amphibious landings. The activity invests in vehicle survivability aspects that are exacerbated due to Size, Weight, Power, Cost constraints inherent to Marine Corps operation and the harsh nature of the amphibious environment. Technologies addressed include lightweight armor for ballistic and underbody blast protection, advanced sensors for counter tactical surveillance, active protection, and signature management. This activity also considers technology for payloads, packages and sensors that are needed by amphibious vehicles (both manned and unmanned) including mine counter measures; explosive hazard defeat systems; and obstacle and threat detection systems as well as technologies for improved protection for individuals against blast, ballistic and blunt impact threats.	6.579	6.670	6.500	0.000	6.500

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602131M / *Marine Corps Lndg Force Tech*	**Project (Number/Name)** 3001 / *Marine Corps Landing Force Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
FY 2019 Plans: This activity is emphasizing developing miniaturized hardware sensing systems for the detection of threats across a variety of sensing modalities to include visual, thermal, RADAR, and Light Detecting and Ranging to take advantage of unique susceptibilities of threat systems at significant ranges. Leveraging these sensor systems, there will be development of computer vision and machine learning approaches for automated target recognition within these innovative sensing modalities. Work also continues to track technologies in the area of passive armor but there will be decreasing investments in this area until basic research in materials science provide opportunities for significant improvement in protection levels. ***FY 2020 Base Plans:*** Research will continue to focus on detecting ambush threats and surveillance of vehicles and personnel prior to reaching threat engagement range. Sensing modalities and advanced algorithms leveraging computer vision and machine learning will continue to be developed to provide counter targeting and tactical surveillance. Improve signature management and control, to include material development, will be explored. Develop improved active protection system countermeasures to expand threat set and protected area and improve robustness to operational environments and enabling technologies for countering unmanned aerial vehicles through kinetic and directed energy means. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: HUMAN PERFORMANCE, TRAINING AND EDUCATION ***Description:*** This activity investigates two technology investment areas, warrior resilience, and decision-making and expertise development. Warrior resilience is focused on advanced training technologies and methodologies that enhance neural, cognitive, and physical readiness. Decision making and expertise development accelerates the development and improves the retention of skills in decision making, situation awareness, and individual and team adaptability and coordination on decentralized, dynamic and dispersed battlefields. ***FY 2019 Plans:*** As efforts decrease in the areas of trauma mitigation and functional movement studies, focus will shift towards simulation-based training, operational decision tools, and physical training tools. Rapid advances in artificial	3.153	3.687	3.700	0.000	3.700

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602131M / *Marine Corps Lndg Force Tech*	**Project (Number/Name)** 3001 / *Marine Corps Landing Force Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
intelligence and terrain and environment collection have provided an opportunity to explore potential impacts into tactical unit-level infantry training and mission planning. Efforts will investigate means with which to document, classify, and data collect on current training programs enabling the development of tools to enhance these programs to increase effectiveness and minimize injury. Efforts will also include an increase in training tools for operation in Electronic Warfare (EW) and Cyber contested environments. ***FY 2020 Base Plans:*** Across the three technology investment areas of 'Warrior Resilience' (WR), 'Decision Making and Expertise Development' (DMED), and Operational Tools (OT) research will continue to focus on providing small unit leaders with effective training and tools to gain them the winning edge on the battlefield. These capabilities will provide information to the warfighter at the point of friction and with increased information flow ("the right information, presented the right way, at the right time") to aid cognitive reasoning about the effects of the battlefield - whether physical or physiological - and mitigation of negative aspects of combat. The WR portfolio will fund research into further understanding the necessity, and ability, to train front-line (infantry) troops for maximum performance. The DMED portfolio will research and implement state-of-the-art and science of learning-based training techniques to improve the development of small unit decision making expertise. The Operational Tools portfolio will increase the ability of the warfighter to process information and speed decision making by implementing novel data collection techniques (multi-spectral collection of signals across the electro-optical spectrum) and processing of these inputs for display - in real time, as the ultimate goal - directly to the individual who requires the information to make a timely, accurate decision. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no change from FY 2019 to FY 2020.					
Title: INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE (ISR) ***Description:*** This activity investigates enhanced situational awareness, persistent surveillance, and tactical decision making through automated analysis of data and rapid integration of information and acquired knowledge. Specific technologies in this activity effectively present actionable information to decision-makers, especially those at the lower command levels. This includes biometric monitoring for expeditionary operations, operational course of action (COA) development, and autonomous surveillance in support of distributed operations.	6.553	6.969	6.276	0.000	6.276

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602131M / *Marine Corps Lndg Force Tech*	**Project (Number/Name)** 3001 / *Marine Corps Landing Force Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
FY 2019 Plans: This activity will begin to divest investments in hardware centered approaches to low power sensing and advanced optical components for multi-spectral imagers. However, investments in smart graphs, network shaping metrics, actionable visualizations will continue. Increased focus will be on investments in context aware (smart) Artificial Intelligence (AI), automation, machine learning, deep learning, and computer vision algorithms. Additionally work will begin on research in strong artificial intelligence applied to the domain of decision support (memory neural networks) and in context adaptive pattern recognition systems (looping), as well as to leverage foundational theory for reinforced learning ***FY 2020 Base Plans:*** Conduct research in applying supervised learning and unsupervised learning algorithms to the Naval domain. Continue development of strong Artificial Intelligence as applied to both images and text. Accelerate development of algorithms that can infer patterns in common intelligence and tactical pictures useful to the development of decision support tools. Accelerate the development of planners that can learn from historical data. Develop a question answering capability that is relevant to the Naval domain. Exam network formation, growth and fracture. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: USMC FNC TECHNOLOGY CANDIDATES ***Description:*** This R-2 Activity, formerly named USMC Future Naval Capabilities (FNCs), addresses the applied research associated with the Marine Corps' participation in the Department of the Navy's (DoN) Future Naval Capabilities (FNC) Program. The objective of the work in this Program Element (PE) is to develop and mature technologies needed by the Marine Corps to initiate FNCs in PE 0603640M Marine Corps Advanced Technology Development (ATD) that can be commenced at higher Technology Readiness Levels (TRLs). Investments in this activity are coordinated with similar and non-duplicative efforts in PE 0602750N Future Naval Capabilities Applied Research, where the Navy's participation in the FNC Program is funded. The FNC Program was restructured for FY19 to accelerate transition to the Fleet and Force. This restructuring involved a zero based review of all ongoing FNC projects where each effort was assessed for its technology maturity and transition commitment. Ongoing efforts were categorized as FNCs or Technology Candidates. Some	4.630	4.799	4.800	0.000	4.800

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total

efforts were terminated and others were accelerated to achieve the goals of the restructured program. FNCs, which have higher Technology Readiness Levels (TRLs of 4/5 to 6) and transition funding commitments, are being resourced in PE 0603640M Marine Corps Advanced Technology Development (ATD). Funding for technology candidates at lower TRLs (3 to 4) is being resourced in this PE. ONR is working closely with the Resource Sponsors and acquisition stakeholders to develop high priority technological capabilities needed by the operational forces.

Prior to FY19, the underlying FNC Program investments in this PE were aligned to specific FNC projects. In order to increase agility, exploit technology advances, and respond quickly to naval needs, future applied research investments supporting FNC technology candidates are being developed in a more flexible manner. This approach facilitates an optimum response when developing and maturing the technology options that will be developed further in PE 0603640M Marine Corps Advanced Technology Development (ATD). The FNC Program has been fully restructured in favor of a more direct and higher level of collaboration. Investments are organized to enhance collaboration with the acquisition stakeholders and their resource sponsors.

A complete accounting of the technologies being developed in this PE will be provided separately to the Congressional oversight committees.

FY 2019 Plans:
The technologies being pursued under this activity include, but are not limited to, investments that focus on developing and maturing new capabilities for asymmetric and irregular warfare, distributed operations, information dominance, maneuverability, survivability, self-defense and expeditionary warfare.

FY 2020 Base Plans:
Future Naval Capability Technology Candidate development in FY20 will continue to focus on a broad range of technologies including, but are not limited to, investments that focus on developing and maturing new capabilities for asymmetric and irregular warfare, distributed operations, information dominance, maneuverability, survivability, self-defense and expeditionary warfare.

FY 2020 OCO Plans:
N/A

FY 2019 to FY 2020 Increase/Decrease Statement:

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602131M / *Marine Corps Lndg Force Tech*	**Project (Number/Name)** 3001 / *Marine Corps Landing Force Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
There is no significant change from FY 2019 to FY 2020.					
Title: LOGISTICS	5.589	5.784	6.254	0.000	6.254
Description: This activity investigates the practical discipline and real world application of the deployment, sustainment, reconstitution, and re-deployment of forces engaged in expeditionary operations. Logistics replaces mass with assured knowledge and speed, is equally capable ashore or afloat in austere environments, and is fully scalable to meet uncertain requirements. This includes efficient and responsive force sustainment, planning and directing logistics operations, logistics demand reduction, fleet maintenance, and expeditionary energy. Expeditionary Energy enhances combat capability of expeditionary warfighters by increasing the efficiency and effectiveness of energy production, storage, distribution and use. Beyond traditional energy efforts, this portfolio also looks at other issues, including energy-efficient behaviors and hybridization of energy sources. These pillars are thoroughly integrated and perpetually related in execution. ***FY 2019 Plans:*** This activity includes developing technologies to anticipate and reduce maintenance demands while increasing reliability. This includes applied research and evaluation of advanced manufacturing methods including metal additive manufacturing (AM), friction stir welding and additive friction stir welding, and cold spray for structural repair of Marine Corps equipment. Additional focus will be on developing a thorough understanding of material Process-Structure-Properties-Performance for high hard steel repair and other structural materials. This research area also includes applied research to predict vehicle health and prognostics of remaining useful life for military ground vehicles and equipment in support of Condition Based Maintenance (CBM) goals, while seeking to automate CBM practices through automatic data retrieval and algorithm development. The focus of this investment area includes enhancing combat capability by increasing energy production, storage, distribution, and curbing energy consumption of the individual Marine and other tactical assets. Activities involve applied research into new, rugged, low cost, and high specific power solar cell technologies that are compatible with military use on flexible substrates, while overcoming current limitations including short-lived cell stability and small area cell growth. Additionally, investigations will take place for developing more energy efficient components for the Marine warfighter and high energy and power density technologies to simultaneously curb exponential power use trends, reduce combat load, and enhance mission duration and combat performance. ***FY 2020 Base Plans:***					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602131M / *Marine Corps Lndg Force Tech*	**Project (Number/Name)** 3001 / *Marine Corps Landing Force Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Logistics development in FY20 will focus on the broad range of technologies noted in the FY19 plans section above. Research into friction stir welding, additive friction stir welding, and cold spray for structural repair of Marine Corps equipment will complete. Research will be initiated in artificial intelligence tools to support logistics planning, execution, and combat support. Develop enhancing autonomous logistics aerial/ground asset teaming. Develop cyberphysical security of Digital Manufacturing methods, including Additive Manufacturing. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: MANEUVER	7.696	10.516	9.022	0.000	9.022
Description: This activity investigates new ways and means to land forces and material through contested sea-land surface interfaces and then conduct maneuver warfare. In order to enable future Amphibious Operations, research efforts will support autonomous operations across the sea-surf-ground environment, improved fuel efficiency and speed of amphibious vehicles, amphibious vehicle technologies, water performance, and amphibious payloads to change the dynamics of a surface amphibious assault. This includes the emergence manned-unmanned teaming and autonomous vehicle collaboration. The technologies included in this work address areas of mobility, materials, propulsion, signature reduction, modularity, and unmanned systems. ***FY 2019 Plans:*** Efforts will research advanced mobility technologies and concepts for tactical and combat ground and amphibious vehicles to extend the operational reach and range, enable higher operational tempo over rough terrain, and to provide protection against cyber threats. This activity will emphasize efforts on providing an autonomous capability to the amphibious fleet for maneuver from ship to shore in a contested landing environment. Also planned for development is autonomous perception, path planning, and vehicle controls for amphibious vehicles from small low cost craft, traditional amphibious combat and assault vehicles, and landing craft. Research will develop knowledge and models for characterizing the surf zone impacts on amphibious craft to allow for physics based simulation of unmanned amphibious craft transition from sea to land environments. Also to be explored are vision based perception systems capable of robust object recognition and complex					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602131M / *Marine Corps Lndg Force Tech*	**Project (Number/Name)** 3001 / *Marine Corps Landing Force Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
scene understanding in dynamic environments. In addition efforts will address technologies that can lead to next generation manned ground vehicles. ***FY 2020 Base Plans:*** Research will focus on intelligent mobility technologies to enable greater capability in harsh off road and littoral environments. Efforts will include better understanding of the ground interface through terrain characterization and researching enhanced platform effectors that allow the system to adapt to varying terrain approaching real time thereby increasing operational tempo. Efforts also include the development of forward-operating autonomous unmanned systems, in communication limited and Global Positioning System denied environments, with a focus on sense-making from local-sensors at the edge. Research will continue to improve the impacts of the surf zone and other land-sea interfaces on vehicle dynamics. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The decrease from FY 2019 to FY 2020 is due to the completion of Modernization Enhanced Experimentation efforts.					
Title: EXPEDITIONARY CYBER ***Description:*** This activity provides freedom of maneuver and influence in the cyber-electronic warfare domain while simultaneously denying the same to the adversary and protecting critical command systems. Technologies are being developed using a multi-disciplinary approach that combines Radio Frequency electronics, digital signal processing, computer engineering, software engineering, machine learning and data science to support Naval Expeditionary warfighters operating with size, weight and power constrained equipment in Disrupted, Intermittent, Limited environments. Areas of applied research include distributed precision time, predictive software defined radio architectures, coordinated Cyber and Spectrum maneuver to mitigate detection and exploitation, tactical Cyber visualization, discovering and mapping networks in dense urban environments, contextual awareness and blind channel characterization. ***FY 2019 Plans:*** Cyber related encryption and multiple-domain processing tools are developed to enable a new class of portable devices that can securely transfer information across multiple tactical user platforms. Research is performed on the phenomenology of cyber battle damage on a class of systems, and results are used to develop hardware and algorithms for assessing cyber system health. Develop and test a new class of component technologies,	6.690	3.574	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602131M / *Marine Corps Lndg Force Tech*	**Project (Number/Name)** 3001 / *Marine Corps Landing Force Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
architectures, and embedded algorithms that demonstrate improved cyber Electronic Warfare resilience. Technologies are developed to perform autonomic monitoring and self-healing of EW-cyber, Command, Control, Communications and Computers and information exchange systems. Cyber behavior research will also be performed on a class of autonomous systems to demonstrate optimized stability, efficiency and resiliency. ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2019 to FY 2020 decrease is due realignment of Expeditionary Cyber from this Project and Activity to Project 2958 Cyberspace Activities for FY 2020.					
Title: FUTURE CONCEPTS, TECHNOLOGY ASSESSMENT, AND ROADMAPPING	1.355	1.593	1.434	0.000	1.434
Description: This activity supports the planning and integration of technology development efforts across the entire Program Element (PE). In conjunction with the Concepts Based Capabilities System and the Marine Corps Warfighting Laboratory, unique and novel concepts for advanced warfighting are developed and validated. Effectiveness analyses are conducted to identify the synergistic effects that can be achieved through the integration of emerging technology with innovative tactics, doctrine, and techniques. Technology assessments are conducted to determine the supporting technologies that have the highest impact across the warfare areas, and warrant further investment within this PE. Technology Roadmapping is conducted to help identify opportunities to leverage technology development within the Department of the Navy and the Department of Defense, as well as, with the commercial sector and university communities. The resultant technology investment strategy is developed and used to guide out-year technology development efforts. ***FY 2019 Plans:*** Assess technologies that best address warfare environments and drivers described in the Marine Corps Operating Concept (MOC) and the Navy's A Design for Maintaining Maritime Superiority. This includes technologies within expeditionary design constraints that exploit scientific opportunities, and develop technology concepts to enable the execution of maneuver warfare in environments characterized by complex terrain including dense urban, technology proliferation, information used as a weapon, battles of signatures, and an increasingly contested maritime domain. Focus on and assess strategies that develop and field more flexible and adaptive technology quicker and with unit costs that win battlefield economics. Create roadmaps and concepts					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602131M / *Marine Corps Lndg Force Tech*	**Project (Number/Name)** 3001 / *Marine Corps Landing Force Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
that enhance expeditionary capabilities against peer and near-peer adversaries whose technologies rival our own. Explore science and technology approaches that can speed up assessment, exploitation, and delivery of capability to expeditionary warfighters. ***FY 2020 Base Plans:*** Assess systems of technologies that best address warfare environments and drivers described in the MOC and the Navy's A Design for Maintaining Maritime Superiority. Identify and integrate numerous technology options within expeditionary design constraints to develop technology counterparts to Operational Concepts. Create technology roadmaps, concepts, and holistic systems of systems approaches that fulfil the needs identified in Operational Concepts such as the Marine Corps' Expeditionary Advanced Based Operations Concept and Littoral Operations in a Contested Environment Concept and enhance expeditionary capabilities against peer and near-peer adversaries. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Accomplishments/Planned Programs Subtotals	52.595	56.212	50.331	0.000	50.331

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

The primary objective of this PE is the development of technologies to meet unique Marine Corps needs in conducting Expeditionary Maneuver Warfare and Combating Terrorism. The program consists of a collection of projects categorized by critical warfighting function. Individual project metrics reflect the technical goals of each specific project. Typical metrics include the advancement of related Technology Readiness Levels, the degree to which project investments are leveraged with other performers, reduction in life cycle cost upon application of the technology, and the identification of opportunities to transition technology to higher categories of development.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602131M / *Marine Corps Lndg Force Tech*	Project (Number/Name) 9999 / *Congressional Adds*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	1.931	7.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	8.931

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Program Increase	1.931	0.000
FY 2018 Accomplishments: Conduct Applied Research associated with two major thrust areas supporting Marine Corps warfighting capabilities. Cyber-Development of active cyber defense techniques - Conduct Cyber-Development of active cyber defense techniques on relevant tactical vehicles. Demonstrate these active defense techniques in a lab environment. Construct attacks for INL benchmark model to determine if Cyber Physical model can detect intrusion via metrics. Cyber technique development against UAS threat. Development of local time and frequency event scenarios associated with low level transient system dynamics needed to measure and control transient responses. Asset Lifecycle Management - Conduct research for new sensors and integrated vehicle health management systems for emerging vehicle programs and prototypes, such as the Armored Reconnaissance Vehicle, in order to enhance overall asset lifecycle management. While existing and prior research has been targeted to supporting the large legacy fleets through leverage of existing vehicle sensors and controller area networks, this research will investigate new asset health data sensing systems to support more advanced diagnostics and prognostics asset management capabilities.		
FY 2019 Plans: N/A		
Congressional Add: Interdisciplinary Expeditionary Cybersecurity Research	0.000	5.000
FY 2018 Accomplishments: N/A		
FY 2019 Plans: This program will fund the following research efforts in FY19:		

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602131M / *Marine Corps Lndg Force Tech*	**Project (Number/Name)** 9999 / *Congressional Adds*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
- Identification of system vulnerabilities within blue and gray cyberspace that affect Expeditionary Cyber operations - Develop proof of vulnerabilities, where applicable - Propose defensive technologies and methodologies for target platforms		
Congressional Add: Marine Corps Asset Life-Cycle Management ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Conduct research for new sensors and integrated vehicle health management systems for emerging vehicle programs and prototypes, such as the Armored Reconnaissance Vehicle, in order to enhance overall asset lifecycle management.	0.000	2.000
Congressional Adds Subtotals	1.931	7.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other Projects.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602235N *I Common Picture Applied Research*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	35.846	36.348	49.297	-	49.297	49.431	52.157	53.923	56.685	Continuing	Continuing
0000: *Common Picture Applied Research*	0.000	35.846	36.348	49.297	-	49.297	49.431	52.157	53.923	56.685	Continuing	Continuing

A. Mission Description and Budget Item Justification

The efforts described in this Program Element (PE) are based on investment directions as defined in the Naval Research and Development Framework. This strategy is based on needs and capabilities from Navy and Marine Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It provides the vision and key objectives for the essential science and technology efforts that will enable the continued supremacy of U.S. Naval forces in the 21st century. The Strategy focuses and aligns Naval S&T with Naval missions and future capability needs that address the complex challenges presented by both rising peer competitors and irregular/asymmetric warfare.

Activities and efforts in this program examine concepts and technologies that enable the transformation to network centric warfare. Network centric capabilities rely on information to connect assets and provide timely and accurate understanding of the environment. The mission area requirements for rapid, accurate decision-making; dynamic, efficient, mission-focused communications and networks; and pervasive and persistent sensing drive network centric S&T investments.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	36.450	36.348	36.486	-	36.486
Current President's Budget	35.846	36.348	49.297	-	49.297
Total Adjustments	-0.604	0.000	12.811	-	12.811
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.604	0.000			
• Program Adjustments	0.000	0.000	12.811	-	12.811
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602235N *I Common Picture Applied Research*

Change Summary Explanation

The funding increases in FY 2020 reflects the increased emphasis and investment in Artificial Intelligence related applied research associated with advancing naval capabilities for decision making tools, systems, and supporting technologies.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602235N / *Common Picture Applied Research*	Project (Number/Name) 0000 / *Common Picture Applied Research*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *Common Picture Applied Research*	0.000	35.846	36.348	49.297	-	49.297	49.431	52.157	53.923	56.685	Continuing	Continuing

A. Mission Description and Budget Item Justification

The activities described in this Program Element (PE) address future Navy and Marine Corps capabilities needed to maintain maritime superiority and ensure national security. They are based on input from Naval Research Enterprise (NER) stakeholders (including the Naval enterprises, the combatant commands, OPNAV and Headquarters Marine Corps) and are designed to exploit breakthroughs in science and technology in order to deliver maximum warfighting benefit to our sailors and marines. These efforts are aligned with shared priorities throughout the whole of RDT&E in order to quickly advance new capabilities from discovery to deployment across the warfighting domains.

Activities and efforts in this program examine concepts and technologies that enable the transformation to network centric warfare. Network centric capabilities rely on information to connect assets and provide timely and accurate understanding of the environment. The mission area requirements for rapid, accurate decision-making; dynamic, efficient, mission-focused communications and networks; and pervasive and persistent sensing drive network centric S&T investments.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: COMMUNICATION AND NETWORKS	7.283	7.242	7.223	0.000	7.223
Description: The overarching objective of this activity is to develop high throughput dynamic wireless communications and network technologies critical to the mission performance and robustness of naval communications for widely dispersed, mobile air, land, surface and submerged platforms. These platforms are often Size, Weight and Power (SWaP) limited, and will operate under constraints of cluttered Radio Frequency (RF) spectrum, harsh Electro-Magnetic Interference (EMI) and Beyond Line Of Sight (BLOS) conditions. The technical payoff is increased network data rates, interoperability across heterogeneous radios, dynamic bandwidth management, and greater mobile network connectivity. The operational payoff is that warfighters from the operational command to the tactical edge have near real-time access to information, knowledge and decision-making necessary to perform their tasks, including coalition and allied forces. Emphasis is on tactical edge communications and networks to fully realize net-centric warfare, bridging the Global Information Grid (GIG) and the 'disadvantaged user', e.g., small-deck combatants, submarines, unmanned vehicles, distributed sensors and ground units in urban and RF challenged environments. The current specific objectives are:					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602235N / *Common Picture Applied Research*	**Project (Number/Name)** 0000 / *Common Picture Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
- Radios and Apertures: Develop technologies for high band radio, electrically-small and actively scanned antennas, addressing critical issue of radio spectrum bandwidth efficiency, spectrum contention and clutter, agile frequency communications with dynamic spectrum access, all-digital front-end with wide dynamic range, power amplifier efficiency, multipath effects, saltwater propagation and BLOS communications. Develop algorithms and signal processing for space-time-frequency diversity communications, including measures for electronic protection, such as low-intercept, antijam waveforms and modulation. Develop affordable antenna technologies for small size and weight, high radiation efficiency, and wideband operation with rapid beam-steering. Develop alternatives to RF communications in airborne and terrestrial environments as well as high data rate underwater communications for undersea warfare (distributed sensor netting, unmanned underwater vehicle data exfiltration, submarine Communications at Speed and Depth) using electro-optic/infra-red (EO/IR) technologies. Develop secure, high bandwidth communications systems and the exploitation of existing and emerging network protocols that will avail development of new, Low Earth Orbit (LEO) based data transport mechanisms. - Tactical Networking and Network Control/Management: Develop advanced networking techniques for robust, highly dynamic environments; interoperable networks for secure communications and protocols, bandwidth and network management techniques that manage and allocate bandwidth across tactical and theater levels in support of net-centric operations. Develop rapidly auto-configuring and self-organizing networks with efficient and survivable routing, secure authentication, mobility management and Quality-of-Service guarantee, while optimizing network resources. Address low bandwidth, synchronization and reliability for Service Oriented Architecture (SOA)/middleware architecture in both mobile ad-hoc networks (MANET) and infrastructure-based Internet Protocol (IP) backbone networks. Develop cognitive network planning and operations engines whose criteria are based directly on mission objectives, while self-adapting and managing the spectrum allocation and radio resources in such a way that network operations, SOA community of interest, and computer network defense are integrated to form a single common tactical network picture that requires a minimum of human intervention and skill. ***FY 2019 Plans:*** Information Technology: Objective is to provide resilient and effective network-centric and information warfare capability for the Navy/ Marine Corps by addressing deficiencies and science gaps in tactical networks. These capabilities address unique military environment and application challenges enabling new mission concepts requiring minimal human intervention. Current work and near-term plans focus on three specific objectives: dynamic network structural analytics and adaptation; robust network organization and transport, distributed group collaboration					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602235N / *Common Picture Applied Research*	**Project (Number/Name)** 0000 / *Common Picture Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
and discovery; and adaptive signaling and sensing to improve military wireless communications. Specific research examples include increasing the performance of low powered networks by using compressed sensing technology and technology to improve the design of distributed and cooperative Intelligence, Surveillance and Reconnaissance (ISR), Integrated Cyber and Electronic Warfare (ICE) operations in denied and contested Electromagnetic environments. Conduct ongoing research and related thrusts in antenna technology to include electrically small antennas, wideband multifunction antennas, compatibility of phased array antennas with naval platforms and marine environments, directional beam forming/steering techniques, and special-purpose submarine communication antenna systems; radio communications to include anti-jam and low-probability-of-intercept techniques, Satellite Communication (SATCOM) performance enhancements, interference mitigation, adaptive equalization, bandwidth efficient modulation, cognitive radio for dynamic spectrum management, and high data rate tactical communications techniques including communications at speed and depth (for submarines); and wireless networks to include mobile ad-hoc wireless networking algorithms/protocols, end-to-end Quality-of-Service, joint/coalition interoperability, service oriented tactical networking, mission-based policy and network controls and management.					
FY 2020 Base Plans: Communications and Networks: Continue ongoing research and related thrusts in antenna technology to include electrically small antennas, wideband multifunction antennas, compatibility of phased array antennas with naval platforms and marine environments, directional beam forming/steering techniques, and special-purpose submarine communication antenna systems; radio communications to include anti-jam and low-probability-of-intercept techniques, Satellite communications (SATCOM) performance enhancements, interference mitigation, adaptive equalization, bandwidth efficient modulation, cognitive radio for dynamic spectrum management, and high data rate tactical communications techniques including communications at speed and depth (for submarines); and wireless networks to include mobile ad-hoc wireless networking algorithms/protocols, end-to-end Quality-of-Service, joint/coalition interoperability, service oriented tactical networking, mission-based policy and network controls and management. Initiate new efforts and research supporting the development of a transmission signal waveform that is less detectable, but operates with higher capacity for a given range, than existing waveforms.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602235N / *Common Picture Applied Research*	**Project (Number/Name)** 0000 / *Common Picture Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Information Technology: Continue work to provide secure, resilient, effective network-centric and information warfare capability for the Navy/Marine Corps by addressing deficiencies and science gaps in tactical networks. These capabilities address unique military environment and application challenges enabling new mission concepts requiring minimal human intervention. Current work and near-term plans focus on three specific objectives: dynamic network structural analytics and adaptation; robust network organization and transport, distributed group collaboration and discovery; and adaptive signaling and sensing to improve military wireless communications. Current research projects will deliver technology for high assurance Field-Programmable Gate Array (FPGA) application design, technology for increasing the performance of low powered networks by using compressed sensing technology, and technology to improve the design of distributed and cooperative Intelligence, Surveillance and Reconnaissance (ISR), Integrated Cyber and Electronic Warfare (ICE) operations in denied and contested Electromagnetic environments. Develop a transmission signal waveform that is less detectable, but operates with higher capacity for a given range, than existing waveforms. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: APPLIED INFORMATION SCIENCES FOR DECISION MAKING	21.915	22.434	35.336	0.000	35.336
Description: The goal of this activity is to develop enablers for decision making and mission execution, to achieve battlespace superiority. It focuses on the development of algorithms and software technologies that identify and integrate informational content from multiple sources, leading to decision aids that support user-cognitive processes. Because persistent sensors are generating massive amounts of data, the focus is on technologies that not only integrate information from diverse sources, but also provide indications of information significance in ways that support the user's decision needs, regardless of location and operational situation. To achieve this, it must be possible to automate understanding of the battlespace by identifying objects, determining relationships among the objects, assessing intent, and automatically generating courses of action with associated risks and uncertainty. Effort will also be devoted to developing technology for increasing assurance and security for Consultation, Command and Control (C3) information systems and technology for improving information discovery and information presentation in such systems. The Nano Electronics Technology activity is focused on developing ultra-low power, higher performance computing devices and components that are based on novel functionalities of nanometer scale materials and are enabled by improved understanding of					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602235N / *Common Picture Applied Research*	**Project (Number/Name)** 0000 / *Common Picture Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
nanomaterials, new devices and circuit design concepts, as well as new architectures uniquely suited for nanoscale systems.Applied research in artificial intelligence for the unique challenges of the Naval domain including providing intelligent decision aiding while operating in the complex spatio-temporal environments of distributed Naval forces. ***FY 2019 Plans:*** Information Technology: Objective is to improve the operational capability and security of Naval decision support systems and decrease the cost of these systems through transformative advances in information management that enables agility in timely and accurate decision and action. The military capability from this task area is technology to support improved situational awareness and operational effectiveness, improved techniques for dealing with information-intensive applications, and information management processes that improve the speed and accuracy of decisions and actions. Specific research examples include technology to detect and remediate security vulnerability in Commercial-off-the-Shelf software, technology to identify and locate individuals of interest using multi-biometrics, technology for goal driven autonomous systems, and technology to improve performance of Navy Watchstand personnel who must monitor multiple workstations concurrently. Electromagnetic Warfare: The technologies being developed are advancing the state-of-the-art in being able to uniquely identify target of interest in very complex environments using passive technologies to assure high confidence to the decision maker when combined with other information sources. This is being accomplished by expanding specific emitter identification technologies into areas detecting previously unaddressed and unexplored to maintain battlespace superiority. Quantum Information Sciences: Conduct research of Quantum Key Distribution (QKD) protocols and implementations for the purpose of understanding the security implications for QKD in the maritime environment, the development of protocols that simultaneously minimize leakage of information to the environment and the creation of secure networks, as well as schemes to maximize the information carried by a continuous or discrete variable; and research of algorithms for naval functions such as routing, weapon-target pairing, etc., a key application such as radar cross section calculation. Computational Methods for Decision Making:					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602235N / *Common Picture Applied Research*	**Project (Number/Name)** 0000 / *Common Picture Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Conduct research of Information Integration, Automated Image Understanding, and Resource Optimization for the purpose of developing innovative methods for combining traditional and non-traditional data from sensors and disparate sources to provide the best estimate of objects, events, and conditions in the battlespace, in terms of their identity, associated error or uncertainty, context, impact, while inferring relationships and their intentions; developing automated, image and signal intelligence understanding tools based on rigorous mathematical and statistical methods that lead to improved change detection, improve object and activity detection and recognition capabilities, context and scene understanding, and inferring of the threat levels to support decision making and persistent and adaptive surveillance; and developing automated decision-support tools based on mathematically rigorous techniques (e.g., mathematical optimization) that support decision-making to ensure the best use of scarce and/or expensive resources, achieving optimal allocations for large complex scenarios, including ones that contain uncertainty, in drastically reduced amounts of time. Develop methods that support decision making in networked sensor management and allocation to ensure sensor assets are deployed in an optimal, or near optimal, manner. The amount of data that the decision makers are facing today is much larger than any time before in human history. In addition, the data is much more complex, heterogeneous and fast changing. Analysis of such large and complex datasets is beyond the cognitive abilities of any single decision maker. The aim of this thrust is to develop new methods for extraction and analysis of relevant information from large-scale datasets, and to develop new tools for distributed information sharing and decision-making. To achieve this aim, it is required to advance fundamental understanding of networks (such as social and organizational networks), and to integrate rigorous methods from mathematical and computational sciences with methods from social sciences. Nanoscale Electronics Technology: Conduct research in novel nanometer scale (feature size near or below 10nm) logic/memory devices and related circuits and architectures to deliver ultra-low power, light weight and high performance computational capability for autonomous vehicles and individual warfighters. Cyber Defense: Conduct research in cyber systems, leveraging results from basic research program, developing and evaluating technical approaches for future naval capabilities. The program investigates technologies for enhancing efficiency, robustness and cyber resiliency for all classes of computing systems in naval enterprise systems as well as Navy's real-time safety critical cyber physical systems. Data Analytics:					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602235N / *Common Picture Applied Research*	**Project (Number/Name)** 0000 / *Common Picture Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Conduct research in new approaches to support tactical decision makers and information superiority. This is performed by producing distributed situation assessment of a commander's environment through development of a common tactical picture; developing collaborative, distributed mission plans; monitoring and dynamically re-planning mission execution as required; understanding their environment by being able to access distributed heterogeneous enterprise information stores intelligently through use of autonomic software; effectively using sensor information and making resource allocation decisions and information operations. Specific research involves real-time computing, decision aids and collaborative workspaces; secure distributed architectures; and information warfare methods to protect secure information.					
FY 2020 Base Plans: Quantum Information Sciences: Conduct research of quantum key distribution (QKD) protocols and implementations for the purpose of understanding the security implications for QKD in the maritime environment, the development of protocols that simultaneously minimize leakage of information to the environment and the creation of secure networks, as well as schemes to maximize the information carried by a continuous or discrete variable. Conduct research into interconversion of optical and mechanical quantum states for memory and potential processing tasks. Computational Methods for Decision Making: Conduct research of Information Integration, Automated Image Understanding, and Resource Optimization for the purpose of developing innovative methods for combining traditional and non-traditional data from sensors and disparate sources to provide the best estimate of objects, events, and conditions in the battlespace, in terms of their identity, associated error or uncertainty, context, impact, while inferring relationships and their intentions; developing automated, image and signal intelligence understanding tools based on rigorous mathematical and statistical methods that lead to improved change detection, improve object and activity detection and recognition capabilities, context and scene understanding, and inferring of the threat levels to support decision making and persistent and adaptive surveillance; and developing automated decision-support tools based on mathematically rigorous techniques (e.g., mathematical optimization) that support decision-making to ensure the best use of scarce and/or expensive resources, achieving optimal allocations for large complex scenarios, including ones that contain uncertainty, in drastically reduced amounts of time. Develop methods that support decision making in networked sensor management and allocation to ensure sensor assets are deployed in an optimal, or near optimal, manner. The amount of data that the decision makers are facing today is much larger than any time before in human history. In addition, the data is much more complex, heterogeneous and fast changing. Analysis of such large and complex datasets is beyond the cognitive abilities of any single decision maker. The aim of this thrust is to develop new methods					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602235N / *Common Picture Applied Research*	**Project (Number/Name)** 0000 / *Common Picture Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
for extraction and analysis of relevant information from large-scale datasets, and to develop new tools for distributed information sharing and decision-making. To achieve this aim, it is required to advance fundamental understanding of networks (such as social and organizational networks), and to integrate rigorous methods from mathematical and computational sciences with methods from social sciences. Imitate new research to study the interplay of three phenomena, heterogeneous and dynamically generated input data from various sources, online decisions, and online learning. Develop methods for integrating massive amounts of diverse data, and present useful information to a tactical commander for planning. Develop new ways to extract and understand human/content interactions to build an algorithm of personalized learning actions for learning and training purposes. Nanoscale Electronics Technology: Conduct research in novel nanometer scale (feature size near or below 10nm) logic/memory devices and related circuits and architectures to deliver ultra-low power, light weight and high performance computational capability for autonomous vehicles and individual warfighters. Initiate exploration of ultra-low power computing applications utilizing mixed signal neuromorphic chips. Cyber Defense: Conduct research in cyber systems, leveraging results from basic research program, developing and evaluating technical approaches for future naval capabilities. The program investigates technologies for enhancing efficiency, robustness and cyber resiliency for all classes of computing systems in naval enterprise systems as well as Navy's real-time safety critical cyber physical systems. Continue efforts to matures technologies and continue work to introduce new capabilities into many cyber security areas, such as automated cryptographic design exploration, cyber decoys and disinformation, automated Commercial off-the- shelf (COTS) cyber attack surface reduction, intrinsic cyber attack resilient industrial control systems, and many more. Addressing the root cause of cyber vulnerability and reducing reliance to operator is one of the main theme of the program. Data Analytics: Conduct research in new approaches to support tactical decision making and assured networked command and control. This is performed by producing distributed situation assessment of a commander's environment through development of a common tactical picture; developing collaborative, distributed mission plans; monitoring and dynamically replanning mission execution as required; understanding their environment by being able to access distributed heterogeneous enterprise information stores intelligently through use of autonomic software; effectively using sensor information and making resource allocation decisions and information operations. Specific research involves real-time computing, decision aids and collaborative workspaces; secure distributed architectures; and information warfare methods to protect secure information.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602235N / *Common Picture Applied Research*	**Project (Number/Name)** 0000 / *Common Picture Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Initiate new research efforts supporting the development of a set of Assured C2 applications that can operate in challenging communications environments. Electromagnetic Warfare: Continue efforts to research and develop technologies for advancing the state-of-the-art in being able to uniquely identify target of interest in very complex environments using passive technologies to assure high confidence to the decision maker when combined with other information sources. This is being accomplished by expanding specific emitter identification technologies into areas detecting previously unaddressed and unexplored to maintain battlespace superiority. Information Technology: Objective is to improve the operational capability and security of Naval decision support systems and decrease the cost of these systems through transformative advances in information management that enables agility and timely, accurate decision making. The military capability from this task area is technology to support improved situational awareness and operational effectiveness, improved techniques for dealing with information-intensive applications, and information management processes that improve the speed and accuracy of decisions and actions. New research projects will deliver technology for Deep Learning networks that can explain their decisions, improved hydraulic efficiency for meso-scale robotic systems, and adaptive memory for long duration autonomous systems. Applied research on artificial intelligence in support of: Collaborative complex decision-making; Developing artificial intelligence technologies that actively inform and assist different stages of the decision making process; Developing interfaces and dialogue systems for human-machine teaming; Developing agile intelligent cognitive electronic warfare algorithms and architectures; Integrating artificial intelligence with robotic systems for human-machine collaboration and robot training; and Predictive maintenance (digital twin) for Naval platforms.					
FY 2020 OCO Plans: N/A					
FY 2019 to FY 2020 Increase/Decrease Statement:					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602235N / *Common Picture Applied Research*	**Project (Number/Name)** 0000 / *Common Picture Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
The funding increases from FY 2019 to FY 2020 reflects the increased emphasis and investment in Artificial Intelligence related applied research associated with advancing naval capabilities for decision making tools, systems, and supporting technologies.					
Title: MULTI-SOURCE INTEGRATION AND COMBAT IDENTIFICATION ***Description:*** This activity addresses Theater Air And Missile defense (TAMD), and responds to warfighter needs for rapid, high confidence Combat Identification (CID) of air and missile threats at long range, using real time and non-real time threat attributes and intelligence information. ***FY 2019 Plans:*** Electromagnetic Warfare: A small sized design has been built to improve RF detection of targets at HF frequencies as precursors to adversary air attacks. This in conjunction with improvements being made in HF surface wave radar array geometries should greatly improve operational capabilities in this reinvigorated part of the RF spectrum. A new concept for rapidly assessing concurrent multiple missiles with multiple EW responses is being investigated to provide for rapid high quality assessment in this complex environment. ***FY 2020 Base Plans:*** Electromagnetic Warfare: Continue efforts to improve RF detection of targets at HF frequencies as precursors to adversary air attacks and improvements in HF surface wave radar array geometries. Continue work on concepts for rapidly assessing concurrent multiple missiles with multiple EW responses to provide for rapid high quality assessment in this complex environment. Expand ship signatures analysis for certain threat categories to determine how to mitigate vulnerabilities and develop methods for robust countermeasures employment. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.	1.530	1.535	1.550	0.000	1.550
Title: TACTICAL SPACE EXPLOITATION	5.118	5.137	5.188	0.000	5.188

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602235N / *Common Picture Applied Research*	**Project (Number/Name)** 0000 / *Common Picture Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Description: The Tactical Space Exploitation initiative explores the application of new space craft technologies on small, light-weight and low-cost satellites, to enhance naval warfighting capabilities by taking advantage of the global access, revisit and connectivity provided by orbital platforms. Spacecraft Technology: Affordable, expendable payload and bus technologies will be developed, which will serve as building blocks for future responsive space systems: payloads, bus technologies and significant space robotic technologies that address on-orbit inspection, servicing, repair and assembly, and mission-life extension. ***FY 2019 Plans:*** Space Research and Spacecraft Technology: Continue development of advanced, high-payoff technologies that will preserve, protect, and enhance space capabilities in the performance of functions that are of critical importance to Navy-Marine Corps operations while also reducing the cost of DoD space activities. Next-Generation Sensing: Conduct effort to develop a single pixel camera architecture for passive microwave imaging, maintaining currently delivered spatial resolution and calibration performance while significantly reducing current aperture diameter. Spacecraft Technology: Initiate development of a new capability for local Space Situational Awareness (SSA) with a novel system that detects and tracks objects in close proximity to a satellite that is equipped with this capability. ***FY 2020 Base Plans:*** Space Research and Spacecraft Technology: Continue efforts to advanced, high-payoff technologies that will preserve, protect, and enhance space capabilities in the performance of functions that are of critical importance to Navy-Marine Corps operations while also reducing the cost of DoD space activities. Next-Generation Sensing: Continue efforts to develop a single pixel camera architecture for passive microwave imaging, maintaining currently delivered spatial resolution and calibration performance while significantly reducing current aperture diameter.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602235N / *Common Picture Applied Research*	**Project (Number/Name)** 0000 / *Common Picture Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Spacecraft Technology: Continue work to develop a new capability for local space situational awareness (SSA) with a novel system that detects and tracks objects in close proximity to a satellite that is equipped with this capability. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Accomplishments/Planned Programs Subtotals	35.846	36.348	49.297	0.000	49.297

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

This PE supports the development of technologies that enable Information Warfare including communications and information assurance capabilities to enable all-source data access, tailored dissemination of information to Command and Control (C2) and Intelligence, Surveillance and Reconnaissance (ISR) users across the network, and rapid, accurate decision making based on this information. The operational benefits sought are increased speed of response, accuracy, and precision of command; distributed self-synchronization; flexibility and adaptability to an operational situation; and decision superiority.

Specific examples of metrics under this PE include:
- Increase network data rates and interoperability across heterogeneous radios; improve dynamic bandwidth management and mobile network connectivity.
- Increase the understanding of the battlespace by the development of automated tools for extracting information from images and signals, identifying objects, determining relationships among the objects, assessing intent, and generating courses of action.
- Improve the integration of sensors, networks, decision aids, weapons, and supporting systems into a highly adaptive, human-centric, comprehensive maritime system.
- Improve integrated signals electronics packages in small, light-weight, and low-cost satellites to test new concepts for global ship tracking and two-way data exfiltration.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602236N *I Warfighter Sustainment Applied Res*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	48.606	65.782	63.825	-	63.825	64.558	66.263	67.788	68.361	Continuing	Continuing
0000: *Warfighter Sustainment Applied Res*	0.000	48.606	58.882	63.825	-	63.825	64.558	66.263	67.788	68.361	Continuing	Continuing
9999: *Congressional Adds*	0.000	0.000	6.900	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.900

A. Mission Description and Budget Item Justification

This Program Element (PE) supports innovation-based efforts that will provide technology options for future Navy and Marine Corps capabilities. Efforts focus on advanced Naval materials; biocentric technologies; environmental quality; human factors and organizational design; medical technologies; and Naval training technologies. Within the Naval Transformation Roadmap, this investment maps to future transformational capabilities and the FORCEnet pillar of the CNO and the Commandant of the Marine Corps vision for the future -- Naval Power 21.

This PE supports the Office of Naval Research (ONR) Global mission to serve as the preeminent external facilitator for the Naval Research Enterprise. This is accomplished by establishing quality, relevant connections between the international research and development community, Naval fleet/forces, DOD, other US Government agencies and international partners.

The efforts described in this Program Element PE are based on investment directions as defined in the Naval Research and Development Framework which is developed from Navy and Marine Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It provides the vision and key objectives for the essential science and technology efforts that will enable the continued supremacy of U.S. Naval forces in the 21st century. Strategy focuses and aligns Naval S&T with Naval missions and future capability needs that address the complex challenges presented by both rising peer competitors and irregular/asymmetric warfare.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602236N *I Warfighter Sustainment Applied Res*

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	48.649	56.197	56.133	-	56.133
Current President's Budget	48.606	65.782	63.825	-	63.825
Total Adjustments	-0.043	9.585	7.692	-	7.692
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	9.585			
• Congressional Directed Transfers	-	-			
• Reprogrammings	1.000	0.000			
• SBIR/STTR Transfer	-1.043	0.000			
• Program Adjustments	0.000	0.000	7.692	-	7.692

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Program Increase*	0.000	2.400
Congressional Add: *Warfighter Safety and Performance*	0.000	4.500
Congressional Add Subtotals for Project: 9999	0.000	6.900
Congressional Add Totals for all Projects	0.000	6.900

Change Summary Explanation

The funding increase from FY 2019 to FY 2020 is due to the original PE structure being retained. Warfighter Sustain Applied Research project reflects the realignment of resources from PE: 0603671N (U)Navy Advanced Technology Development(ATD) Proj. 3433 for Human Research Protection Program (HRPP) back into PE: 0602236N Warfighter Sustainment Applied Res Proj: 0000 and into the Human Research Protection Program (HRPP) R2 Activity.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602236N / *Warfighter Sustainment Applied Res*	Project (Number/Name) 0000 / *Warfighter Sustainment Applied Res*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *Warfighter Sustainment Applied Res*	0.000	48.606	58.882	63.825	-	63.825	64.558	66.263	67.788	68.361	Continuing	Continuing

A. Mission Description and Budget Item Justification

Efforts in this PE focus on; advanced naval materials; biocentric technologies; environmental quality; human factors and organizational design; medical technologies; international science and science advisor programs; and Naval systems training and education.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: ADVANCED NAVAL MATERIALS	11.004	11.455	14.715	0.000	14.715
Description: Advanced Naval Materials efforts support several Science and Technology (S&T) Focus Areas, in particular Platform Design & Survivability, and perform research across a broad spectrum of technical areas including: structural materials to increase platform performance and survivability at reduced weight and cost; advanced, high-performance materials for energy systems; corrosion mitigation strategies; high-temperature propulsion systems; and enhanced sonar transducers. ***FY 2019 Plans:*** ADVANCED NAVAL MATERIALS: Conduct research on structural materials to include the following: Nanostructured materials processing, composite development, cellular materials, high temperature materials and alternative hull materials. Conduct applied research related to critical S&T to investigate corrosion control modeling, high strength corrosion resistant compositionally complex alloys, corrosion resistant additive manufactured alloys and acoustic transduction technologies. MATERIALS AND PROCESSES: Development of novel and scalable processing methods to produce mechanically robust high temperature superconductor tapes with minimal AC loss for various naval applications such as transformers, inductors, stators and for pulsed power delivery systems for all electric ships. Conduct design new microfluidic system for direct write additive manufacturing to significantly improve the existing techniques. Design multifunctional material systems for use in new helmet design to mitigate multiple threats. Conduct compositional modifications					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602236N / *Warfighter Sustainment Applied Res*	**Project (Number/Name)** 0000 / *Warfighter Sustainment Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
and processing parameters to optimize material performance that have been demonstrated, leading to current plans for their utilization. ***FY 2020 Base Plans:*** -Conduct research on Agile Manufacturing Integrated Computational Materials Engineering (ICME). This effort will establish a robust collection of predictive capabilities based on quantitative experimentation and characterization at all appropriate length scales to accelerate the development and optimization of new materials, and the design of advanced components while reducing the time required for qualification. Application of these tools will enable greater confidence and utilization of additive manufacturing and other advanced manufacturing technologies. -Conduct ongoing research on materials development and advanced processing technologies for acoustic transduction. - Conduct research on structural materials to include the following: nanostructured materials and coatings processing, composite development, cellular materials, high temperature materials, metals and alloys for structural applications, and alternative hull materials. - Conduct applied research related to critical S&T to investigate corrosion control modeling, high strength corrosion resistant coatings and compositionally complex alloys, and corrosion resistant additive manufactured alloys. -Conduct ongoing research that develops enabling manufacturing technology to scale up and improve affordability of science and technology products. Key tasks for this period include development of affordable fabrication technology for submarine coatings. Materials and Chemistry: Develop novel and scalable processing methods to produce mechanically robust high temperature superconductor tapes with minimal AC loss for various naval applications such as transformers, inductors, stators and for pulsed power delivery systems for all electric ships. Design new microfluidic system for direct write additive manufacturing to significantly improve the existing techniques. Design of multifunctional material systems for use in new helmet design to mitigate multiple threats. Compositional modifications and					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602236N / *Warfighter Sustainment Applied Res*	**Project (Number/Name)** 0000 / *Warfighter Sustainment Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
processing parameters to optimize material performance have been demonstrated leading to current plans for their utilization. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increase from FY 2019 to FY 2020 is due to the Agile Manufacturing Integrated Computational Materials Engineering effort initiating in FY20.					
Title: BIOCENTRIC TECHNOLOGIES ***Description:*** Applied research to provide solutions for Naval needs based upon bio-inspired systems, sensors, robotics, and technologies; synthetic biology to produce high-value materials or to develop sentinel organisms; marine mammal diagnostics to support the Navy's Fleet Marine Mammal Systems; and augmented Warfighter performance. ***FY 2019 Plans:*** NAVAL BIOSCIENCE: Conduct research into the development of innovative naval biosensors, biomaterials, and bioprocess technology. Investigate engineering development and optimization of sea-floor sediment energy harvesting system for sustainable and autonomous powering of underwater sensor networks and AUV's. Conduct research on the development of microbial fuel cells for powering a linear sensor array. Study microbial electrochemical systems for shipboard desalination/ waste-to-energy conversion and the closed-loop microbial fuels cells. Research explosive-sensing plants and microbial electrobiosynthesis of liquid fuels. Continue development of microbial electronic devices. SYNTHETIC BIOLOGY FOR SENSING & ENERGY PRODUCTION: Conduct research on synthetic biology studies of engineered sentinel organisms for environmental surveillance and integration of programmable cellular controllers with robotic devices. LIFE SCIENCE AND BIOENGINEERING:	5.709	5.684	7.596	0.000	7.596

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602236N / *Warfighter Sustainment Applied Res*	**Project (Number/Name)** 0000 / *Warfighter Sustainment Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Conduct marine mammal diagnostics efforts, including immunobioassays for stress and infection detection and efforts to detect, treat, and prevent diseases in dolphins, including diabetes and kidney stones. NEURAL, SENSORY AND BIOMECHANICAL SYSTEMS: Conduct efforts on naval biosensor to detect brain structures and blood vessels through skull bones. Investigate advanced biomimetic sensing and neural control for human-robot interaction to enable effective collaboration of warfighters and autonomous systems. Integrate biomimetic sonar with bioinspired autonomous undersea vehicles (with high-lift propulsors)to achieve closed loop control. Conduct research into bioinspired quiet, and maneuverable self-propelled line array using high-lift propulsors based on animal wing and fin biomechanics and in efforts of bio-inspired massively parallel vision systems. Study the development of brain-based intelligent systems to support high level interaction between warfighters and autonomous systems. Continue studies to develop electrosence and biosonar for Mine Counter Measures (MCM) and Explosive Ordinance Device (EOD) missions. MATERIALS AND CHEMISTRY: Conduct development of novel approaches to rapidly identify antibiotic resistant genes in bacterial pathogens of importance for the entire US military force. Success of this effort will enable our transitional partners, the Naval Medical Research Center and the Naval Medical Research Laboratories, for rapid identification of highly resistant bacterial pathogens. A major success has been demonstrated by utilizing NRL developed microbial resistant determinant assay for its advances to system design. ***FY 2020 Base Plans:*** Bio-Inspired Systems: Applied research in areas of: Control of bio-inspired autonomous vehicles in complex maneuvers; and Integration of biomimetic sonar with bio-inspired underwater vehicles for obstacle detection and avoidance. Human Interaction with Autonomous Systems: Applied research in areas of: Development of brain-based intelligent systems to support collaboration between humans and autonomous systems; and Research on human and robotic teammates. Biocentric Technology: Applied research of Naval biosensors, biomaterials, and bioprocess technologies: Accelerate engineering development and optimization of microbial undersea energy harvesting systems for sustainable and autonomous powering of Naval underwater sensor and communication nodes; Examine					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602236N / *Warfighter Sustainment Applied Res*	**Project (Number/Name)** 0000 / *Warfighter Sustainment Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
feasibility of microbial electrochemical systems for shipboard waste-to-energy conversion (including disabled submarine scenarios); Accelerate research in human microbiome for divers, combat swimmers, and submariners; Applied research of devices incorporating engineered sentinel organisms for environmental monitoring (including the human gut); and Integration of programmable cellular controllers with robotic devices. Bioengineering and Life Sciences: Applied research in the areas of: Sequencing technologies as diagnostic tools for viral pathogens in chemical and environmental samples; Various formulations of polymer mimics of mussel adhesion proteins for underwater applications; Highly-efficient proton exchange membrane fuel cells based on designer catalysts and novel catalyst supports for Naval applications; and Improving the health and welfare of the Navy's marine mammals including development of immunobioassays for stress and infection detection and acoustic analysis of dolphin sounds as an indicator of their well-being; Warfighting Augmentation: Applied research in multi-functional textiles that interact with autonomous life support, neuromuscular control and waste management, biosensors and bio-electronics, and adaptive and integrative protection. Materials and Chemistry: Develop novel approaches to rapidly identify antibiotic resistant genes in bacterial pathogens of importance for the entire US military force. Success of this effort will enable our transitional partners, the Naval Medical Research Center and the Naval Medical Research Laboratories, for rapid identification of highly resistant bacterial pathogens. A major success has been demonstrated by utilizing Naval Research Laboratory (NRL) developed microbial resistant determinant assay for its advances to system design. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increases from FY19 to FY20 reflects Biocentric Technologies R2 Activity focus to reduce scope in decision support/uncertainty analysis for operational environments, and increase scope in providing solutions for Naval needs based upon bio-inspired systems.					
Title: ENVIRONMENTAL QUALITY ***Description:*** Environmental Quality technologies enable sustained world-wide Navy operations in compliance with all local, state, regional, national and international laws, regulations and agreements.	2.574	2.764	2.672	0.000	2.672

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602236N / *Warfighter Sustainment Applied Res*	**Project (Number/Name)** 0000 / *Warfighter Sustainment Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
FY 2019 Plans: - Development of new, advanced, environmentally benign Anti-Fouling (AF)/Anti-Corrosive (AC) coating systems for Navy platforms. - Development of advanced environmentally sound technologies for shipboard waste treatment and pollution abatement systems. - Conduct field evaluation of prototype robotic Hull BUG to identify gaps needed to refine and advance the technology for reduced drag, and significant fuel savings. ***FY 2020 Base Plans:*** - Ongoing development of new, advanced, environmentally benign Anti-Fouling (AF)/Anti-Corrosive (AC) coating systems for Navy platforms. - Ongoing development of advanced environmentally sound technologies for shipboard waste treatment and pollution abatement systems. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: HUMAN FACTORS AND ORGANIZATIONAL DESIGN ***Description:*** Applied research to improve system interface designs and human-level decision support in Naval contexts. Research areas include human-machine teaming, social networks and computational social science, and command decision making. ***FY 2019 Plans:*** HUMAN COMPUTER INTERACTION/VISUALIZATION: Conduct research on audio-visual cue integration for 360-degree periscope displays by utilizing eye-tracking, sleep studies and traditional behavioral measures to characterize human performance on periscope-related tasks under a variety of physiological conditions.	5.161	5.777	5.745	0.000	5.745

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602236N / *Warfighter Sustainment Applied Res*	**Project (Number/Name)** 0000 / *Warfighter Sustainment Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
COMMAND DECISION MAKING (CDM): Development of task management algorithms applicable to agile supervisory control of teams involving human and autonomous agents. Research the development of an information infrastructure that is operational context sensitive to allow the dynamic prioritization of date based on its anticipated information value and mission criticality. Study building proactive decision support tools for Command and Control. Investigate Navigating in Uncertainty. SOCIAL NETWORK ANALYSIS: Initiate development of warfighting experiments for information environment assessment, civil-military communications (public affairs), information operations and psychological operations. ***FY 2020 Base Plans:*** Human-Machine Teaming: Applied research on system interface designs and human-machine interaction methodologies that enable or enhance Warfighter performance and human-machine teaming. Focus areas include: (i) Physiological monitoring and cognitive state estimation; (ii) Psychoacoustics and audio-visual scene interpretation; and (iii) Rapid interface design evaluation. Social Networks and Computational Social Science: Applied research in information environment assessment, civil-military communications (public affairs) information operation, and psychological operations. This research addresses problems of countering influence operations, dealing with polarized audiences, and mitigation of social hysteria propagation in online and real-world information campaigns. These efforts include gamification to provide principles and foundational frameworks for development of training and exercises, including operating in contested information environments. Command Decision Making: Applied research in decision aid algorithms and human interfaces for command and control processes, to include alerting command staff when mission re-planning is required. Research technologies to capture and share practical knowledge that is learned on the job and effectively share with peers as a supplement to formal training. Conduct applied research for the development of supervised learning algorithms that capture mission planning workflow for a range of missions. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: MEDICAL TECHNOLOGIES	6.462	5.839	5.771	0.000	5.771

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602236N / *Warfighter Sustainment Applied Res*	**Project (Number/Name)** 0000 / *Warfighter Sustainment Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Description: Applied research in reducing operational health threats and enhancement of human performance; development of point-of-injury medical equipment, diagnostic capabilities and treatments; technologies to improve Warfighter safety and to enhance personnel performance under adverse conditions. To prevent duplication of effort, research is coordinated with other Services through the Armed Services Biomedical Research Evaluation and Management (ASBREM) Committee. ***FY 2019 Plans:*** UNDERSEA MEDICINE: Conduct efforts to reduce operational injuries. Study Decompression Sickness (DCS) and Arterial Gas Embolism (AGE), to include novel approaches to the prevention, detection and treatment of DCS/AGE, particularly by non-recompressive methods. Investigate the development of prophylactic agents preventing hyperbaric oxygen toxicity. Prolonged exposure to hyperbaric oxygen can be toxic to lungs, nervous system and eyes. Study the optimization of diver and submariner health and performance when exposed to a variety of environmental and unique stressors (heat and cold, prolonged deployments, effects of altered diurnal rhythms, non-standard breathing gases, lack of sunlight, etc). Explore novel pharmaceutical interventions for hyperbaric oxygen toxicity. Continue research on improving performance in extreme environments including integrated diving helmet audio-visual displays; human-machine symbiosis; nutrition, hydration and gut microbiome studies; and genomics/ metabolomic approaches. REGENERATIVE MEDICINE: Continue the program with the Armed Forces Institute for Regenerative Medicine (AFIRM). NOISE INDUCED HEARING LOSS (NIHL): Conduct research to reduce noise at the source, i.e. jet engine quieting and flight deck noise reduction. Study the biomedical effects of underwater sound as military divers must operate safely and effectively in potentially complex underwater sound fields. Mitigate the impact of exposure to stressful combat environments prior to deployment through "stress inoculation". Study the incidence, susceptibility, and mitigation strategies of NIHL and tinnitus. Research the					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602236N / *Warfighter Sustainment Applied Res*	**Project (Number/Name)** 0000 / *Warfighter Sustainment Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
prevention, treatment and reversal of NIHL and tinnitus. Investigate the improvement of personal protective equipment technology. Continue Jet Noise Reduction Project to utilize analytical modeling and simulation tools anchored by experiment to develop and assess solutions enabling mitigation of jet induced noise from high performance tactical aircraft. ***FY 2020 Base Plans:*** Undersea Medicine and Performance: Applied research efforts include: Integrated diving helmet audio-visual displays; and Pharmacological agents and technologies to mitigate decompression sickness and oxygen toxicity. Sensory Neuroscience and Whole-body Physiology: Applied research to improve personal protective equipment and monitoring systems in order to mitigate biomedical effects of exposure to high-levels of acoustic pressure or electromagnetic energy. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: HUMAN RESEARCH PROTECTION PROGRAM (HRPP)	0.000	2.685	2.705	0.000	2.705
Description: Part 46 of Title 45, Code of Federal Regulations (CFR), Protection of Human Subjects (henceforth: "Common Rule") is codified in the Department of Defense (DoD) as 32 CFR 219, and implemented through DoD Instruction 3216.02, which is the policy that must be followed for human subjects research conducted, supported, or otherwise subject to regulation by any federal department or agency. The Secretary of the Navy Instruction SECNAVINST 3900.39E identifies the Chief of Naval Research (CNR) as providing support and expertise for human research protection in the systems commands, operational forces, training commands and DON-supported non-DoD institutions. The HRPP program satisfies the aforementioned regulations and policies by: 1) ensuring that research involving human subjects complies with Federal, DoD, and DON research protection requirements; and 2) providing education programs in human research ethics to all levels of staff involved in the review, approval, conduct, management, or support of DON research involving human subjects. ***FY 2019 Plans:*** Implement the DON Human Research Protection Program (HRPP) in the Navy's Systems Commands, operational forces, training commands, and DON-supported research involving human subjects performed					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602236N / *Warfighter Sustainment Applied Res*	**Project (Number/Name)** 0000 / *Warfighter Sustainment Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
by non-DoD institutions, and enforce regulatory compliance in human subjects research conducted and supported by the DON. Specific tasks include: DON-wide training for the revised Common Rule at 45 Code of Federal Regulations Part 46 Subpart A, develop new Human Research Protection Programs for 3 non-medical commands, and create non-medical DON human research protection community of excellence network ***FY 2020 Base Plans:*** Execute DON HRPP Management Plan; provide day-to-day oversight of DON HRPP activities; conduct periodic site inspections and assist visits; conduct training for Exempt Determination Officials, conduct Component and Headquarters-level review of DON-supported human subjects research; provide subject matter expertise and guidance on all DON-supported research involving human subjects; implement revisions to Standard Operating Procedures in light of revisions to the Common Rule and SECNAVINST 3900.39E; and provide DON input to USD(R&E) and other DoD policy guidance impacting DON human research-related efforts. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increase from FY 2019 to FY 2020 reflects the realignment of resources from PE: 0603671N (U)Navy Advanced Technology Development(ATD) Proj. 3433 for Human Research Protection Program (HRPP) back into PE: 0602236N Warfighter Sustainment Applied Res Proj: 0000 and into the Human Research Protection Program (HRPP) R2 Activity.					
Title: THE OFFICE OF NAVAL RESEARCH GLOBAL ***Description:*** Supports the Office of Naval Research (ONR) Global mission to serve as the preeminent external facilitator for the Naval Research Enterprise. This is accomplished by establishing quality, relevant connections between the international research and development community, Naval fleet/forces, DOD, other US Government agencies and international partners. Science Advisors (SA): This effort ensures that the operational Naval fleet/force help shape the DON investment in science and technology (S&T), develops teaming relationships to rapidly prototype, experiment, demonstrate and transition technology, supports development of technology-based capability options for Naval forces, and enables warfighting innovations based on technical and conceptual possibilities. The SA Program also informs capability-based war games using current and future technology to identify future capability strengths and shortfalls that assist in shaping the DON investment strategy. The ONR Global SA Program enables continuous	12.737	19.760	19.733	0.000	19.733

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602236N / *Warfighter Sustainment Applied Res*	**Project (Number/Name)** 0000 / *Warfighter Sustainment Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
communication and collaboration between the warfighters, the Naval Research & Development Enterprise, and strategic development commands. INTERNATIONAL SCIENCE: The ONR Global mission is also accomplished through PhD-level scientists located in Asia, Europe and South America, providing coverage in these regions as well as Africa, Australia/ New Zealand and the Middle East. ONR Global scientists actively search the globe for emerging scientific research and promising technologies, collaborating with international organizations and researchers through liaison visits and grants in innovative applied research. The direct impact of this investment is to leverage international research during increasingly dynamic global interdependence and improve the ability to solve DON S&T challenges through shared knowledge and technologies with partners. In addition, this investment builds global S&T awareness to reduce the risk of potential technological surprise, and supports theater security cooperation goals to sustain cooperative relationships with an expanding set of international partners. INTERNATIONAL ENGAGEMENT: ONR Global also supports international engagement with partner nations through the development and maintenance of bilateral and multilateral relationships, international agreements, and other activities that promote RDT&E collaboration and interoperability. ***FY 2019 Plans:*** ONR Global will support 28 PhD level scientists, in seven overseas offices, continuing to engage with international scientists and engineers through liaison visits to research institutions and continue actively fostering international collaboration by awarding research grants. ***FY 2020 Base Plans:*** - Support all Science Advisor program efforts across Fleet and Forces Commands; objectively assess placement of current Science Advisors and requests for additional support in terms of impact to the Fleet and S&T return on investment. -Support PhD-level scientists, in seven overseas offices, continuing to engage with international scientists and engineers through liaison visits to research institutions and continue actively fostering international collaboration by awarding research grants.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602236N / *Warfighter Sustainment Applied Res*	**Project (Number/Name)** 0000 / *Warfighter Sustainment Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
- Support international engagement with ten partner nations, three multi-lateral groups, and support to the Northern Atlantic Treaty Organization (NATO), in order to increase collective Naval capability, capacity, and interoperability. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: TRAINING TECHNOLOGIES ***Description:*** Applied research to enhance the Navy's ability to "train as they fight" in classroom settings, simulated environments, and during deployment to operate effectively in complex, high stress, information-rich, and ambiguous environments of modern warfare. Improved efficiency and cost-effectiveness is achieved by applying operations research, modeling and simulation, and instructional, cognitive, and computer sciences to the development, delivery, evaluation, and execution of training and education. To prevent duplication of effort, research is coordinated with other Services via the Human Systems Community of Interest. ***FY 2019 Plans:*** COGNITIVE SCIENCE OF LEARNING: Conduct research and associated efforts to assess advanced gaming technology for enhanced training. Conduct experiments to validate automated performance assessment and after action reviews. Development a systematic program of applied research addressing unanswered questions regarding effective instructional strategies in artificially intelligent tutoring. Conduct research the neurobiology of learning including integration of the role of white matter. Develop games that incorporate Artificial Intelligence (AI) techniques to teach complex warfighter skills decision-making and problem solving. Continue work to develop optimal training strategies for intelligent jobs on mobile devices (e.g., IPad) and immersive environments for training interpersonal and leadership skills. Work to design and conduct experiment to assess training effectiveness of intelligent tutor for training ship handling skills. Efforts to design features and develop novel psychometric approaches to assess human performance in medical/military simulations and simulators. Conduct field studies and user tests evaluating new features and job aiding tools. Continue research in computational neuron-models in the design of training systems. Conduct ongoing efforts to develop skill decay models for psychomotor, perceptual, and cognitive skills and refresher training strategies. Work to create intelligent avatars to interact with learners from different cultural, linguistic backgrounds, and preferences. Continue design scenarios generators that produce	4.959	4.918	4.888	0.000	4.888

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602236N / *Warfighter Sustainment Applied Res*	**Project (Number/Name)** 0000 / *Warfighter Sustainment Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
integrated (e.g.,individual and collective) training. Development of computational model for learning theory to drive design of instruction and continue research on individual differences. ENHANCING WARFIGHTER COGNITIVE CAPABILITY: Conduct research to understand the structural relations among the latent variables of short-term memory, working memory, executive attentional control, and fluid intelligence. Work to assess the improvement in recruit classification provided by the addition of measures of fluid intelligence and working memory. Efforts to understand the role of intrinsic motivation in facilitating the transfer of working memory training to other cognitive capabilities. Continue the study the efficacy of game-based brain training using hand-held (fieldable) hardware platforms. Conduct work to determine the relationship between induced gains in fluid intelligence and cognitive adaptability and agility, considered from the perspective of military decision-making. Develop multi-agent based architectures for modeling human behavior, improve techniques for human cognitive and behavioral modeling, and create highly realistic simulated teammates. COMPUTATIONAL MODELS OF HUMAN BEHAVIOR: Research game based training to more effectively enable better warfighter understanding of languages and cultures to enhance their regional expertise. Development of software tools to facilitate building natural language tutorial dialogs for artificially intelligent tutoring. Continue integration of cognitive and neuron-computational models of human learning. ***FY 2020 Base Plans:*** Technologies for Naval Training: Applied research to augment training, skill maintenance, and evaluation through gaming, and learning theory. Research includes developing effective instructional strategies in intelligent tutors and conducting evaluation of intelligent job aids. Develop computational models of skill decay for psychomotor, perceptual, and cognitive skills, and refresher training strategies. Advanced Integrated Maritime Mission Modeling: Applied research in the development of live, virtual, and constructive training and experimentation technologies. Efforts will include developing tools for training in denied and degraded electromagnetic environments and in extreme weather environments. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:***					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602236N / *Warfighter Sustainment Applied Res*	**Project (Number/Name)** 0000 / *Warfighter Sustainment Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
There is no significant change from FY 2019 to FY 2020.					
Accomplishments/Planned Programs Subtotals	48.606	58.882	63.825	0.000	63.825

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

As discussed in Section A, there are a significant number of varied efforts within this PE. Each effort is measured against both technical and financial milestones. Each program effort and its projects are reviewed in depth for technical and transition performance against established goals. The Program Managers conduct routine site visits to performing organizations to assess programmatic and technical progress and most projects conduct an annual or biannual review by an independent board of visitors who assess the level and quality of the Science and Technology (S&T) basis for the project.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602236N / *Warfighter Sustainment Applied Res*	Project (Number/Name) 9999 / *Congressional Adds*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	0.000	6.900	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.900

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Program Increase ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Research into social networks and the impact of novel technologies on human behavior in crisis and collaborative contexts.	0.000	2.400
Congressional Add: Warfighter Safety and Performance ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Conduct research to include: continued studies on decompression sickness, oxygen toxicity, optimization of diver performance, and assessment of the impact of thermal stress on operational performance.	0.000	4.500
Congressional Adds Subtotals	0.000	6.900

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other Projects.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602271N *I Electromagnetic Systems Applied Research*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	83.640	76.497	83.497	-	83.497	83.259	86.875	91.575	93.272	Continuing	Continuing
0000: *Electromagnetic Systems Applied Research*	0.000	77.846	76.497	83.497	-	83.497	83.259	86.875	91.575	93.272	Continuing	Continuing
9999: *Congressional Adds*	0.000	5.794	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	5.794

A. Mission Description and Budget Item Justification

The activities described in this Program Element (PE) address future Navy and Marine Corps capabilities needed to maintain maritime superiority and ensure national security. They are based on input from Naval Research Enterprise stakeholders (including the Naval enterprises, the combatant commands, OPNAV and Headquarters Marine Corps) and are designed to exploit breakthroughs in science and technology in order to deliver maximum warfighting benefit to our sailors and marines. These efforts are aligned with shared priorities throughout the whole of RDT&E in order to quickly advance new capabilities from discovery to deployment across the warfighting domains.

The Electromagnetic Systems Applied Research Program addresses technology needs associated with Naval platforms for new capabilities in Electro-Optic and Infrared (EO/IR) Sensors, Surveillance, Electronic Warfare, Navigation, Solid State Electronics, Vacuum Electronics Power Amplifiers, and Nanoelectronics. The program supports development of technologies to enable capabilities in Missile Defense, Directed Energy, Platform Protection, Time Critical Strike, and Information Distribution. This program directly supports the Department of Defense Joint Warfighter Plan and the Defense Technology Area Plans. Activities and efforts within this Program have attributes that focus on enhancing the affordability of warfighting systems. The program also provides for technology efforts to maintain proactive connectivity and collaboration between Department Of the Navy (DON) Science and Technology (S&T) and Joint, Navy, and Marine Corps commands worldwide.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	79.598	83.800	81.815	-	81.815
Current President's Budget	83.640	76.497	83.497	-	83.497
Total Adjustments	4.042	-7.303	1.682	-	1.682
• Congressional General Reductions	-	-0.126			
• Congressional Directed Reductions	-	-7.177			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.856	0.000			
• Program Adjustments	0.000	0.000	1.682	-	1.682

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy					Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*		R-1 Program Element (Number/Name) PE 0602271N *I Electromagnetic Systems Applied Research*			
• Rate/Misc Adjustments	-0.001	0.000	0.000	-	0.000
• Congressional General Reductions Adjustments	-0.101	-	-	-	-
• Congressional Add Adjustments	6.000	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)

	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Program Increase*	5.794	0.000
Congressional Add Subtotals for Project: 9999	5.794	0.000
Congressional Add Totals for all Projects	5.794	0.000

Change Summary Explanation

The program increase supports increased investment in specialized signal processing engines to leverage machine learning algorithms for improved electronic support (ES) and electronic attack (EA) capabilities.

Technical: Not applicable.

Schedule: Not applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
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COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *Electromagnetic Systems Applied Research*	0.000	77.846	76.497	83.497	-	83.497	83.259	86.875	91.575	93.272	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project addresses technology opportunities associated with Naval platforms for new capabilities in EO/IR Sensors, Surveillance, Electronic Warfare, Navigation, Solid State Electronics, Vacuum Electronics Power Amplifiers, and Nanoelectronics. The project supports development of technologies to enable capabilities in Missile Defense, Directed Energy, Platform Protection, Time Critical Strike, and Information Distribution. This project directly supports the Department of Defense Joint Warfighter Plan and the Defense Technology Area Plans. Activities and efforts within this program have attributes that focus on enhancing the affordability of warfighting systems. The program also provides for technology efforts to maintain proactive connectivity and collaboration between Department Of the Navy (DON) Science and Technology (S&T) and Joint, Navy, and Marine Corps commands worldwide.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: ELECTRONIC WARFARE TECHNOLOGY	42.256	38.906	43.534	0.000	43.534
Description: The overarching objective of this activity is to develop technologies that enable the development of affordable, effective and robust Electronic Warfare (EW) systems across the entire Electromagnetic Spectrum (EMS) that will increase the operational effectiveness and survivability of U.S. Naval units. Emphasis is placed on passive sensors and active and passive Countermeasure (CM) systems that exploit and counter a broad range of electromagnetic threats. The focus is on maintaining near perfect, real-time knowledge of the enemy; countering the threat of missiles against deployed Naval forces; precision identification and location of threat emitters; and development of technologies that have broad application across multiple disciplines within the EW mission area. This activity also includes developments to protect these technologies from external interference, and modeling and simulation required to support the development of these technologies. Also included is technology development in support of the Integrated Distributed Electronic Warfare System (IDEWS) concept. The current objectives are: - EW Radio Frequency (RF) Technology: Develop and demonstrate technologies in the RF spectrum (covering frequencies from kilohertz to terahertz) that include developments in detection, signal processing and passive/ active techniques for wideband Electronic Attack (EA), Electronic Protection (EP) and the Electronic Support (ES) mission areas.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602271N / *Electromagnetic Systems Applied Research*	**Project (Number/Name)** 0000 / *Electromagnetic Systems Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
- EW Electro-Optic/Infrared (EO/IR) Technology: Develop and demonstrate technologies in the EO/IR spectral domain (extending from the ultraviolet to the far infrared spectral bands) that include advances in multispectral sensors, multiband sources, beam forming/steering, and signal processing and transmission. - EW Integrated and Networked Technology: Develop and demonstrate technologies that will enable an increased situational awareness and response across the electromagnetic spectrum (EMS) with broad spatial coverage using all available EW assets to provide coordinated, adaptive and networked EW sensing, protection and attack. - Advanced EW Enabling Technologies: Develop classified advanced electronic warfare technology in support of current and predicted capability requirements. - Electromagnetic Maneuver Warfare Command & Control (EMC2) (FY16-FY20): Enable a battle group to work cooperatively in the EM Spectrum (EMS) to optimize Electronic Warfare (EW), Information Operations (IO), Communications (Comms) and Radar performance. EMC2 will build upon the Resource Allocation Manager (RAM) that was previously developed for single multifunction systems under the InTop program to optimize spectrum and functional use across a platform and an entire battle group. ***FY 2019 Plans:*** Electromagnetic Warfare: The research being conducted is very diverse and includes efforts in both Radio Frequency (RF) countermeasures and Electro-Optic and Infrared (EO/IR) Countermeasure including both detection and defeat. Technology developments to provide capabilities indigenous to small UASs are a significant focus. Technology developments being addressed include the development of new optical lens technologies based on Gradient Indexed (GRIN) optics. This latter technology when coupled with another ongoing effort in multidimensional optics show significant promise for greatly reducing the weight of highly capable optical systems. RF efforts include work in developing engineered high transmit to receiver materials for significant improvements in isolation. Efforts in devising means to degrade, disable or defeat operational communications networks is yielding promising results. Work is ongoing to expand Electronic Warfare (EW) jamming capabilities at high power levels covering previously unaddressed frequency bands with significant operational impact. Cognitive electronic attack approaches in both the communications bands and radar bands are ongoing to address the need to address and defeat unidentified RF pop-up threats. Interesting results have been obtained in ongoing research in metamaterials in the RF domain. There is a renewed focus on devising techniques to discover new					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
methods of detecting, identifying, and cataloging threat emissions and also schemes to apply countermeasures using micro jamming constellations Continue research in the areas of improved threat warning systems; Electronic Warfare Support (ES); decoys and countermeasures against weapon tracking and guidance systems; Electronic Attack (EA) against adversary Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR); and Electronic Protection (EP) of our own weapons and C4ISR from intentional and unintentional interference to control the Electromagnetic Spectrum (EMS) by exploiting, deceiving, or denying enemy use of the spectrum while ensuring its use by friendly forces. ***FY 2020 Base Plans:*** Reinvigorate investments in fundamental component technologies that drive performance of electronic warfare system across the range of functions from sensor, signal processing, decision and collaboration software and response. Develop advanced antenna solutions to enable Simultaneous Transmit And Receive (STAR) with high directivity. Innovate new Radio-Frequency (RF) amplifier technology to deliver high power, broadband devices that extend into the millimeter-Wave in small form factors. Leverage emerging compute architectures and advanced algorithms to provide signal processing solutions for operating coherent, distributed arrays in complex electromagnetic environments. Develop deep learning methods for improved electronic warfare functions in the signal processing chain. Apply machine learning techniques to surface self-defense systems. Develop counter-measure solutions to optical sensors including non-mechanical beam steering and laser technologies to increase the effectiveness of Electro-Optic/Infrared (EO/IR) countermeasures in addition to passive obscurant technology. Improve modeling of sensor systems to provide integrated capability across optical and RF domain. Develop test technology for affordable fielding of cognitive, collaborative Electronic warfare (EW) effector systems. Electromagnetic Warfare: The RF domain research includes discovery of communications networks and mechanisms for their disruption and defeat. Selected examples of research include discovery of parameters to identify functional characteristics of emerging radar system, advanced algorithms to specifically identify modern radar sources, using micro-jammers in a phased array configuration, exploiting optical emission characteristics, and development of a novel deep reinforcement learning and Q-network software framework to develop and refine control policies for participating offensive and defensive agents. ***FY 2020 OCO Plans:***					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase from FY 2019 to FY 2020 reflects increased investment in specialized signal processing engines to leverage machine learning algorithms for improved electronic support (ES) and electronic attack (EA) capabilities.					
Title: EO/IR SENSOR TECHNOLOGIES	7.078	7.102	7.141	0.000	7.141
Description: The overarching objective is to develop technologies that enable the development of affordable, wide area, persistent surveillance optical architectures, day/night/adverse weather, adaptable, multi-mission sensor technology comprised of optical sources, detectors, and signal processing components for search, detect, track, classify, Identify (ID), intent determination, and targeting applications and includes developments to protect these technologies from external interference. Also included are modeling and simulation required to support the development of these technologies. Efforts will also include the development of optical Radio-Frequency (RF) components, infrared technologies including lasers and focal plane arrays using narrow bandgap semiconductors. The current specific objectives are: - Optically Based Terahertz (THz) and Millimeter Wave (MMW) Distributed Aperture Systems: Develop optically based terahertz (THz) and millimeter wave distributed aperture systems for imaging through clouds, fog, haze and dust on air platforms. - Wide Area Optical Architectures: Develop wide area optical architectures for persistent surveillance for severely size constrained airborne applications. - Hyperspectral sensors and processing: Develop visible, shortwave Infrared (IR), mid-wave IR, and long-wave IR hyperspectral sensors, along with processing algorithms to detect anomalies and targets. - Coherent Laser Radar (LADAR): Develop and improve components for LADAR applications including fiber lasers, coherent focal planes, and advanced processing. - Autonomous and Networked sensing: Develop algorithms and processing that supports autonomous sensing for Unmanned Autonomous Vehicles (UAV) platforms and that supports networked sensing over multiple sensors and/or sensor platforms.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
FY 2019 Plans: Electromagnetic Warfare: A unique approach permitting rapid active scanning of a battlefield in the IR domain using a non-mechanically scanned mechanism is under development. This technology if successful will eliminate the multiple laser ball systems currently required to accomplish this same requirement at lower SWAP. Active work is also being focused on developing capabilities for high resolution, wide field of view sensors for modest sized UAS platforms. A promising development using holographic-based optical phase conjugation to provide a wide field of view Electro-Optic and Infrared (EO/IR) countermeasures to detect, track and/or jam imaging sensors. An effort is expanding the state of the art in a Short-Wave Infrared (SWIR) multispectral LIDAR system capable of simultaneous 4D (x,y,z,?) spatial-spectral information for imaging and spectral discrimination through obscurations to provide improved battlespace awareness through a revolutionary multi-functional electro-optical system for intelligence, surveillance, reconnaissance, target detection and classification. Continue electronics research efforts and thrusts on new concepts, components, techniques, and subsystems for the generation, and transmission of UV, visible, and infrared radiation to support current and future Navy and DoD needs. Continue Materials and Chemistry focused research and thrusts on advanced fabrication methods to develop micro-retro-reflectors operating in short wavelength Infrared (IR) systems. This study is directed to develop unique spectral bar codes. Major accomplishments include development of high refractive index glass composition Conduct ongoing research in optical components and infrared technologies including lasers and focal plane arrays using narrow bandgap semiconductors for the purpose of imaging through clouds, fog, haze and dust; persistent surveillance for severely size constrained airborne applications; detecting anomalies and targets; and autonomous sensing for UAV platforms and networked sensing over multiple sensors and/or sensor platforms.					
FY 2020 Base Plans: Conduct applied research in optical components, infrared technologies and signal processing for the purpose of affordable, wide area, persistent surveillance and targeting applications in all weather conditions. Specific areas of research include: novel optical architectures for affordable persistent surveillance to support search, detection, classification, identification and targeting functions; development of laser and passive mmW detectors for imaging through degraded visual environments (e.g., clouds, fog, haze and dust); low size, weight, and power					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
hyper-spectral sensors for severely size and power constrained airborne applications; development of automatic algorithms for autonomously detecting and recognizing anomalies and targets using networked sensors and/or sensor platforms; novel techniques for Electro-Optic/Infrared (EO/IR) countermeasures to detect, track and/or jam sensors. Electronics: Create and explore new concepts, components, techniques, and subsystems for the generation, and transmission of Ultra-Violet (UV), visible, and infrared radiation to support current and future Navy and DoD needs. Electromagnetic Warfare: Work is ongoing to address the critical deficiency with respect to operations in brownout conditions. IR and terahertz technologies are being modified and integrated with the expectations that combining these two technologies an effective solution can be obtained. Bistatic radar and imaging technology is being developed to extend surveillance capabilities and passively engage targets. A unique approach permitting rapid active scanning of a battlefield in the IR domain using a non-mechanically scanned mechanism is under development. This technology if successful will eliminate the multiple laser ball systems currently required to accomplish this same requirement at lower Size, Weight and Power (SWAP). Active work is also being focused on developing capabilities for high resolution, wide field of view sensors on modest sized Unmanned Autonomous Systems (UAS) platforms. Materials and Chemistry: Advanced fabrication methods to develop micro-retro-reflectors operating in short wavelength IR systems. This study is directed to develop unique spectral bar codes. Major accomplishments include development of high refractive index glass composition. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: NAVIGATION TECHNOLOGY	6.120	6.110	7.827	0.000	7.827
Description: The overarching objective of this activity is to develop technologies that enable the development of affordable, effective and robust Position, Navigation and Timing (PNT) capabilities using the Global Positioning System (GPS), non-GPS navigation devices, and atomic clocks. This project will increase the operational effectiveness of U.S. Naval units. Emphasis is placed on GPS Anti-Jam (AJ) Technology; Precision Time and					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Time Transfer Technology; and Non-GPS Navigation Technology (Inertial aviation system, bathymetry, gravity and magnetic navigation). The focus is on the mitigation of GPS electronic threats, the development of atomic clocks that possess unique long-term stability and precision, and the development of compact, low-cost Inertial Navigation Systems (INS). The following are non-inclusive examples of plans for projects funded in this activity. ***FY 2019 Plans:*** Continue applied research in position, navigation and timing. This research aims to develop techniques and technology to provide assured, cost-effective, and mission relevant PNT to the warfighter. Areas of investment included robust GPS, non-GPS navigation aids, and assured timekeeping. Specifically, GPS Anti-Jam (AJ) Antennas and Receivers for Navy platforms for the purpose of providing precision navigation capabilities in the presence of electronic threats and anti-spoofer/AJ processors for the purpose of providing precision navigation capabilities in the presence of emergent threats; Tactical grade atomic clocks that possess unique long-term stability and precision for the purpose of providing GPS-independent precision time and transferring GPS-derived time via radio frequency links for the purpose of providing GPS-independent precision time; and Inertial navigation systems for the purpose of providing an alternative means of providing precision navigation, a correlation navigation technique using earth maps of high precision, for those Naval platforms which may not have GPS navigation capabilities and/or loss of GPS signals. ***FY 2020 Base Plans:*** Conduct applied research in position, navigation and timing. This research aims to develop techniques and technology to provide assured, cost-effective, and mission relevant PNT to the warfighter. Areas of investment included robust GPS, non-GPS navigation aids, and assured timekeeping. Specifically, GPS Anti-Jam Antennas and Receivers for Navy platforms for the purpose of providing precision navigation capabilities in the presence of electronic threats and anti-spoofer/anti-jam processors for the purpose of providing precision navigation capabilities in the presence of emergent threats; Tactical grade atomic clocks that possess unique long-term stability and precision for the purpose of providing GPS-independent precision time and transferring Coordinated Universal Time (UTC) as maintained at the United States Naval Observatory (USNO) time via alternative electromagnetic links for the purpose of providing GPS-independent precision time; and Inertial navigation systems for the purpose of providing an alternative means of providing precision navigation, a correlation					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
navigation technique using earth maps of high precision, for those Naval platforms which may not have GPS navigation capabilities and/or loss of GPS signals. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The Increase from FY 2019 to FY 2020 in the Navigation Technology thrust is due to the requirement for expanded investment in quantum based Position, Navigation and Timing (PNT) sensors.					
Title: SOLID STATE ELECTRONICS ***Description:*** The overarching objective of this activity is to develop higher performance components and subsystems for all classes of military Radio-Frequency (RF) systems that are based on solid state physics phenomena and are enabled by improved understanding of these phenomena, new circuit design concepts and devices, and improvements in the properties of electronic materials. An important subclass are the Very High Frequency (VHF), Ultra-High Frequency (UHF), Microwave (MW), and Millimeter Wave (MMW) power amplifiers for Navy all-weather radar, surveillance, reconnaissance, electronic attack, communications, and smart weapon systems. Another subclass are the analog and high speed, mixed signal components that connect the electromagnetic signal environment into and out of digitally realized, specific function systems. These improved components are based on both silicon (Si) and compound semiconductors (especially the wide bandgap materials and narrow bandgap materials), low and high temperature superconductors, novel nanometer scale structures and materials. Components addressed by this activity emphasize the MMW and Submillimeter Wave (SMMW) regions with an increasing emphasis on devices capable of operating in the range from 50 Gigahertz (GHz) to 10 terahertz (THz). The functionality of the technology developed cannot be obtained through Commercial-Off-The-Shelf (COTS) as a result of the simultaneous requirements placed on power, frequency, linearity, operational and instantaneous bandwidth, weight, and size. Effort will involve understanding the properties of engineered semiconductors as they apply to quantum information science and technology. This activity also includes Anti-Tamper development of innovative techniques and technologies to deter the reverse engineering and exploitation of our military's critical technology and critical program information in order to impede technology transfer and alteration of system capability and prevent the development of countermeasures to U.S. systems. ***FY 2019 Plans:*** Electronics:	11.040	12.920	13.520	0.000	13.520

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Explore and develop electronic materials, devices, components, and circuits in the frequency range of ~ 1 MHz to ~ 10 THz that provide system performance edge compared to COTS-based solid state electronics to ensure supremacy of future radar, EW, communications, sensor, and intelligence systems. Continue ongoing research efforts in the areas of solid state transistors and devices for high frequency analog and digital operation; high efficiency, highly linear amplifiers for microwave, millimeter-wave, low-noise, and power applications; superconducting and other technologies which are designed to deliver software defined, wide band, many simultaneous signal functionality over a wide range of frequencies, in increasingly field-ready packaging and demonstrate the ability of these components to deliver superior functionality in conventional system contexts, including, but not limited to, SATCOM, Surveillance EW, Signal Intelligence (SIGINT), and communications; electronics and photonics technology that provides for the control, reception, transmission and processing of signals; and Anti-Tamper: develop a undetectable, robust, low/no power, low cost set of technologies that can be deployed in many different systems from many different vendors for the purpose of protecting critical technology and critical program information contained in U.S. military systems from tampering and reverse engineering.					
FY 2020 Base Plans: Electronics: Ongoing development of electronic materials, devices, components, and circuits in the frequency range of ~ 1 Megahertz to ~ 10 Terahertz that provide system performance edge compared to current state of the art solid state electronics to ensure supremacy of future radar, Electronic Warfare (EW), communications, sensor, and intelligence systems. Continue ongoing research efforts in the areas of solid state transistors and devices for high frequency analog and digital operation; high efficiency, highly linear amplifiers for microwave, millimeter-wave, low-noise, and power applications; superconducting and other technologies which are designed to deliver software defined, wide band, many simultaneous signal functionality over a wide range of frequencies, in increasingly field-ready packaging and demonstrate the ability of these components to deliver superior functionality in conventional system contexts, including, but not limited to, Satellite Communications (SATCOM), Surveillance Electronic Warfare (EW), signal intelligence (SIGINT), and communications; electronics and photonics technology that provides for the control, reception, transmission and processing of signals. Explore and develop new materials, devices, components, and circuits that apply quantum phenomena of entanglement, superposition and/or wave function correlation for performance not achievable by classical methods.					
FY 2020 OCO Plans:					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020					
Title: SURVEILLANCE TECHNOLOGY	8.998	9.093	9.085	0.000	9.085
Description: The overarching objective of this activity is to develop advanced sensor and sensor processing systems for continuous, high volume, theater-wide air and surface surveillance, battle group surveillance, real time reconnaissance and ship defense. Major technology goals include long-range target detection and discrimination, target Identification (ID) and fire control quality target tracking in adverse weather, background clutter and electronic countermeasure environments and includes modeling and simulation required to support the development of these technologies. The current specific objectives are: - Radar Architectures, Sensors, and Software which Address Ballistic Missile and Littoral Requirement Shortfalls: Develop radar architectures, sensors, and software which address Ballistic Missile and Littoral requirement shortfalls including: sensitivity; clutter rejection; and flexible energy management. - Algorithms, Sensor Hardware, and Signal Processing Techniques for Automated Radar Based Contact Mensuration and Feature Extraction: Develop algorithms, sensor hardware, and signal processing techniques for automated radar based contact mensuration and feature extraction in support of asymmetric threat classification and persistent surveillance and to address naval radar performance shortfalls caused by: man-made jamming and Electronic Counter Measures (ECM), unfavorable maritime conditions, and atmospheric and ionosphere propagation effects. - Software and Hardware for a Multi-Platform, Multi-Sensor Surveillance System: Develop software, and hardware for a multi-platform, multi-sensor surveillance system for extended situational awareness of the battlespace. - Small Unmanned autonomous Vehicles (UAV) Collision Avoidance/Autonomy Technology: Develop small UAV collision avoidance/autonomy technology. ***FY 2019 Plans:*** Electromagnetic Warfare:					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Efforts in this area are expanding the surveillance of adversary platforms by developing advanced signal processing techniques to bi-statically detect surface vessels by sensing reflected ubiquitous transmissions and for the detection and discrimination of small UAS in a clutter filled environment. Additionally, technology development to enable full spectrum battlespace awareness through an ultra-wideband aperture for simultaneously 360-degree beamforming and low-profile ultra-low cross-polarization ultra-wide-band apertures to provide resilient electronic protection for Naval platforms. Continue applied research in sensors, networking and communication connectivity for the purpose of developing an affordable and fully automated network of time-coordinated mono-static, bi-static and passive surveillance sensors providing real-time tracking, identification, and engagement information with persistent wide area awareness. Specifics Surveillance Technology research objectives include: Radar - research into antenna apertures, electronics, and signal processing continue to provide enhanced capability to detect, track, and automatically identify targets and threats; Signal Intelligence - the use of interferometric and sophisticated signal processing algorithms enable the detection, geolocation, tracking, and identification of targets; Network Sensing - research areas include sensor data fusion, multi-hypothesis decision making, multi-target tracking, and methods for handling and fusing disparate and intermittent data sources; and Electronic Protection - develop methods to mitigate Electronic Attack (EA) and Electromagnetic Interference (EMI) to Radio Frequency (RF) sensors and networks. ***FY 2020 Base Plans:*** Electromagnetic Warfare: Efforts in this area are expanding the surveillance of adversary platforms by developing advanced signal processing techniques to bistatically detect surface vessels by sensing reflected ubiquitous transmissions and for the detection and discrimination of small Unmanned Autonomous Systems (UAS) in a clutter filled environment. Additionally, technology development to enable full spectrum battlespace awareness through an ultra-wideband aperture for simultaneously 360 degree beamforming and low-profile ultra-low cross-polarization ultra-wide-band apertures to provide resilient electronic protection for Naval platforms. Conduct applied research in sensors, networking and communication connectivity for the purpose of developing an affordable and fully automated network of time-coordinated mono-static, bi-static and passive surveillance sensors providing real-time tracking, identification, and engagement information with persistent wide area awareness. Specifics Surveillance Technology research objectives include: Radar - research into antenna apertures, electronics, and signal processing continue to provide enhanced capability to detect, track, and automatically identify targets and threats; Signal Intelligence - the use of interferometric and sophisticated signal processing algorithms enable the detection, geolocation, tracking, and identification of targets; Network					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Sensing - research areas include sensor data fusion, multi-hypothesis decision making, multi-target tracking, and methods for handling and fusing disparate and intermittent data sources; and Electronic Protection - develop methods to mitigate Electronic Attack (EA) and Electromagnetic Interference (EMI) to RF sensors and networks. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: VACUUM ELECTRONICS POWER AMPLIFIERS	2.354	2.366	2.390	0.000	2.390
Description: The overarching objective of this activity is to develop Millimeter Wave (MMW) and sub-MMW power amplifiers for use in Naval all-weather radar, surveillance, reconnaissance, electronic attack, and communications systems. The technology developed cannot, for the most part, be obtained through Commercial Off The Shelf (COTS) as a result of the simultaneous requirements placed on power, frequency, bandwidth, weight, and size. Responding to strong interests from the various user communities, efforts are focused on the development of technologies for high-data-rate communications, electronic warfare and high-power radar applications at MMW and upper-MMW regime. The emphasis is placed on achieving high power at high frequency in a compact form factor. Technologies include utilization of spatially distributed electron beams in amplifiers, such as sheet electron beams and multiple-beams, and creation of simulation based design methodologies based on physics-based and geometry driven design codes. The current specific objectives are: - High Power Millimeter and Upper Millimeter Wave Amplifiers: Develop science and technology for high power millimeter and upper millimeter wave amplifiers including high current density diamond cathodes, sheet and multiple electron beam formation and mode suppression techniques in overmoded structures. - Lithographic Fabrication Techniques: Develop lithographic fabrication techniques for upper-millimeter wave amplifiers. - Accurate and Computationally Effective Device-Specific Multi-Dimensional Models for Electron Beams: Develop accurate and computationally effective device-specific multi-dimensional models for electron beam					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
generation, large-signal and stability analysis to simulate device performance and improve the device characteristics. ***FY 2019 Plans:*** Electronics Explore and develop electron beam physics, beam-wave interaction structures, microfabrication techniques, Radio Frequency (RF) materials, and physics-based modeling to produce designs and prototypes of compact, efficient, broadband, linear, high power devices operating at mmW & sub-mmW frequencies. Continue ongoing vacuum electronics efforts and increase investment in research associated with the exploration and development of electron beam physics, beam-wave interaction structures, microfabrication techniques, RF materials, and physics-based modeling to produce designs and prototypes of compact, efficient, broadband, linear, high power devices operating at Millimeter Wave (MMW) & sub-MMW frequencies. ***FY 2020 Base Plans:*** Electronics: Exploratory and develop electron beam physics, beam-wave interaction structures, microfabrication techniques, RF materials, and physics-based modeling to produce designs and prototypes of compact, efficient, broadband, linear, high power devices operating at mmW & sub-mmW frequencies. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Accomplishments/Planned Programs Subtotals	77.846	76.497	83.497	0.000	83.497

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602271N / *Electromagnetic Systems Applied Research*	**Project (Number/Name)** 0000 / *Electromagnetic Systems Applied Research*

E. Performance Metrics

This PE supports the development of technologies that address technology needs associated with Naval platforms for new capabilities in EO/IR Sensors, Surveillance, Electronic Warfare, Navigation, Solid State Electronics, Vacuum Electronics Power Amplifiers, and Nanoelectronics. The program supports development of technologies to enable capabilities in Missile Defense, Directed Energy, Platform Protection, Time Critical Strike, and Information Distribution. Each PE Activity has unique goals and metrics, some of which include classified quantitative measurements. Overall metric goals are focused on achieving sufficient improvement in component or system capability such that the 6.2 applied research projects meet the need of, or produce a demand for, inclusion in advanced technology that may lead to incorporation into acquisition programs or industry products available to acquisition programs.

Specific examples of metrics under this PE include:

- Provide a secure, over the horizon, on-the- move capability to communicate with higher headquarters at a data rate of 256-512 Kbps at a cost of $75,000.
- Provide an array configuration suitable for installation on aircraft that will support Tactical Common Data Link (TCDL) data rates of 10.7 and 45 Mbps at greater than 150 nautical mile range.
- Develop prototype Ku band phased array apertures in a form factor suitable for installation on the CVN-78.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602271N / *Electromagnetic Systems Applied Research*	Project (Number/Name) 9999 / *Congressional Adds*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	5.794	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	5.794

A. Mission Description and Budget Item Justification

Provides improved ground-based space situational awareness.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Program Increase	5.794	0.000
FY 2018 Accomplishments: Congressional add supports extension of space situational awareness capabilities by extending the collection period into the daytime hours by demonstrating advanced infrared sensing technologies.		
FY 2019 Plans: N/A		
Congressional Adds Subtotals	5.794	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other Projects.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602435N *I Ocean Wrfghtg Env Applied Res*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	72.530	89.998	63.894	-	63.894	64.143	70.125	76.155	77.187	Continuing	Continuing
0000: *Ocean Wrfghtg Env Applied Res*	0.000	41.145	42.998	63.894	-	63.894	64.143	70.125	76.155	77.187	Continuing	Continuing
9999: *Congressional Adds*	0.000	31.385	47.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	78.385

A. Mission Description and Budget Item Justification

The activities described in this program element (PE) address future Navy and Marine Corps capabilities needed to maintain maritime superiority and ensure national security. They are based on input from Naval Research Enterprise stakeholders (including the Naval enterprises, the combatant commands, OPNAV and Headquarters Marine Corps) and are designed to exploit breakthroughs in science and technology in order to deliver maximum warfighting benefit to our sailors and marines. These efforts are aligned with shared priorities throughout the whole of RDT&E in order to quickly advance new capabilities from discovery to deployment across the warfighting domains.

This PE provides the unique, fundamental programmatic instrument by which basic research on the natural environment is transformed into technological developments that provide new or enhanced warfare capabilities for the Battlespace Environment (BSE). The objectives of this program are met through measuring, analyzing, modeling and simulating, and applying environmental factors affecting naval material and operations in the BSE. This program provides for BSE technological developments that contribute to meeting top joint warfare capabilities established by the Joint Chiefs of Staff, with primary emphasis on Joint Littoral Warfare and Joint Strike Warfare.

This PE fully supports the Director of Defense Research and Engineering's Science and Technology Strategy and is coordinated with other DoD Components through the Defense Science and Technology Reliance process. Work in this program is related to and fully coordinated with efforts in accordance with the on-going Reliance joint planning process. There is close coordination with the US Air Force and US Army under the Reliance program in the BSE categories of Lower Atmosphere, Ocean Environments, Space & Upper Atmosphere, and Terrestrial Environments. Within the Naval Transformation Roadmap, the investment will contribute toward achieving each of the "key transformational capabilities" required by Sea Strike, Sea Shield, and Sea Basing. Moreover, environmental information, environmental models, and environmental tactical decision aids that emerge from this investment will form one of the essential components of FORCEnet (which is the architecture for a highly adaptive, human-centric, comprehensive maritime system that operates from seabed to space). The Navy program includes efforts that focus on, or have attributes that enhance, the affordability of warfighting systems.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602435N *I Ocean Wrfghtg Env Applied Res*

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	42.411	42.998	43.104	-	43.104
Current President's Budget	72.530	89.998	63.894	-	63.894
Total Adjustments	30.119	47.000	20.790	-	20.790
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	47.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.684	0.000			
• SBIR/STTR Transfer	-1.697	0.000			
• Program Adjustments	0.000	0.000	20.790	-	20.790
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
• Congressional Add Adjustments	32.500	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Program Increase*	7.243	0.000
Congressional Add: *AGOR Mid-life Refit*	19.314	0.000
Congressional Add: *Naval Special Warfare Maritime Science and Technology*	4.828	0.000
Congressional Add: *Naval Special Warfare*	0.000	10.000
Congressional Add: *Task Force Ocean*	0.000	10.000
Congressional Add: *Acoustics Research*	0.000	2.000
Congressional Add: *Multi-Modal Detection Research*	0.000	10.000
Congressional Add: *Persistent Maritime Surveillance*	0.000	15.000
Congressional Add Subtotals for Project: 9999	31.385	47.000
Congressional Add Totals for all Projects	31.385	47.000

Change Summary Explanation

The funding change in FY 2020 is due to the need to increase investment in the Ocean Warfighting Environment Applied Research project and the associated support for fleet operations for the current and/or emerging systems of research vessels of the U.S. Academic Research Fleet. Additional funds cover planned

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602435N *I Ocean Wrfghtg Env Applied Res*

costs for operations, maintenance, repair and upgrades that enable applied research at sea and provides modeling and analysis for environmental compliance for ONR and Naval Research Laboratory (NRL) field work and active acoustic experiments.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602435N / *Ocean Wrfghtg Env Applied Res*	Project (Number/Name) 0000 / *Ocean Wrfghtg Env Applied Res*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *Ocean Wrfghtg Env Applied Res*	0.000	41.145	42.998	63.894	-	63.894	64.143	70.125	76.155	77.187	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project provides technologies that form the natural environment technical base on which all systems development and advanced technology depend. Furthermore, this technical base provides developments that may be utilized in the Future Naval Capabilities programs: Organic Mine Countermeasures (MCM) and Autonomous Operations. This project contains the National Oceanographic Partnership Program (NOPP) (Title II, subtitle E, of Public Law 104-201) and efforts aimed at understanding and predicting the impacts of underwater sound on marine mammals.

Major efforts of this project are devoted to: gaining real-time knowledge of the Battlespace Environment (BSE), determining the natural environment needs of regional warfare, providing the on-scene commander with the capability to exploit the environment to tactical advantage and, developing atmospheric research related to detection of sea-skimming missiles and strike warfare. This project provides natural environment applied research for all fleet operations and for current or emerging systems, and continuing support to research vessels of the U.S. Academic Research Fleet for operations, maintenance, repair and upgrades that enable applied research at sea and provides modeling and analysis for environmental compliance for ONR/NRL field work and active acoustic experiments. Major developments are routinely transitioned to the Fleet Numerical Meteorology and Oceanography Center and to the Naval Oceanographic Office where they are used to provide timely information about the natural environment for all fleet operations.

Joint Littoral Warfare efforts address issues in undersea, surface, and air battlespace. Efforts include ocean and atmospheric analysis and prediction for real-time description of the operational environment, shallow water acoustics, multiple-influence sensors for undersea surveillance and weapon systems, and influences of the natural environment on MCM and Anti-Submarine Warfare (ASW) systems. Joint Strike Warfare efforts address issues in air battlespace dominance. Efforts include influences of the natural environment on air operations, electromagnetic (EM)/electro-optic (EO) systems used in intelligence, surveillance, reconnaissance, targeting, bomb damage assessment, and detection of missile weapon systems. They also include improvements in tactical information management about the BSE.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: Coastal Geosciences/Optics	7.775	8.019	11.552	0.000	11.552
Description: The goal of the Coastal Geosciences/Optics activity is to understand and predict the nearshore and coastal battlespace environment and its evolution. Studies address coupled phenomena affecting the hydrodynamical, geological, geophysical, and optical properties of the littorals through development of theory, predictive models and field measurement campaigns. Research results support safe and efficacious Naval Mine, Undersea, and Special Warfare operations.					
FY 2019 Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602435N / *Ocean Wrfghtg Env Applied Res*	**Project (Number/Name)** 0000 / *Ocean Wrfghtg Env Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Research investments in this activity support the development and testing of models, sensors, algorithm development and testing to enable prediction of coastal battlespace environments anywhere on the globe. Efforts include ocean color remote sensing to characterize bathymetry, shallow-water bottom types, and the distribution of ocean water optical properties in the littorals and the demonstration of a compact hyperspectral imager to retrieve coastal environmental products from small UAVS. Additional efforts develop shipboard, in-situ, airborne, and spaceborne sensors and appropriate inversion and though-the-sensor techniques to create operationally and tactically useful environmental descriptions of the littorals and sea bottom. Battlespace Environments: Continue to conceptualize and perform laboratory, field, and numerical modeling studies to understand and exploit various geoscience and optical environmental phenomena in areas that are scientifically challenging, require innovation, and are of interest to the Navy/Marine Corps. Encompasses the design, performance, analysis and underlying theory of field and laboratory experiments designed to understand geological/geophysical, biological, and optical phenomena in the oceans and littoral zones, and to validate that understanding. Continue applied research to develop new or enhance existing shipboard, in-situ, airborne, and spaceborne sensors and appropriate inversion and though-the-sensor techniques to obtain, store, utilize, merge and/or exploit data and create operationally and tactically useful environmental information of the littorals and bottom. Continue specification and development of sensors, signal processing, inversion, and other analysis tools when needed. Undersea Warfare: Conceptualize and perform laboratory and field studies to understand and exploit energy storage and retrieval from the benthic interface and the potential to balance small scale and large scale intermittent power generation with power demand for persistent operation of marine sensors presently powered by batteries.					
FY 2020 Base Plans: Applied research investments in this activity support the development and testing of littoral models, sensors, platforms (air, surface, undersea or space) and remote sensing algorithm development to enable prediction of coastal battlespace environments anywhere on the globe. Efforts include development of new sensors and ocean remote sensing to quantify littoral geophysical variables, e.g., bathymetry, shallow-water bottom types, waves, currents, temperature, salinity, vector winds, optical properties. Battlespace Environments: Conceptualize and perform laboratory, field, and numerical modeling studies to understand and exploit various geoscience and optical environmental phenomena in areas that are scientifically					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602435N / *Ocean Wrfghtg Env Applied Res*	**Project (Number/Name)** 0000 / *Ocean Wrfghtg Env Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
challenging, require innovation, and are of interest to the Navy/Marine Corps. Encompasses the design, performance, analysis and underlying theory of field and laboratory experiments designed to understand geological/geophysical, biological, and optical phenomena (including bioluminescence), in the oceans and littoral zones, and to validate that understanding. To develop models that can predict bottom boundary physical, geological, geochemical, geo-acoustic and geotechnical properties in shallow-water operating areas requires: a) an improved understanding of processes that generate and modify the shape, structure and physical properties of the seafloor and sub-seafloor, and its topography/morphology. Includes efforts to develop new or enhance existing shipboard, in-situ, airborne, and space-borne sensors and appropriate inversion and though-the-sensor techniques to obtain, store, utilize, merge and/or exploit data and create operationally and tactically useful environmental information of the littorals and bottom. This includes specification and development of sensors, signal processing, inversion, and other analysis tools when needed. Surveillance of coastal land areas and waters is important to support Navy operations. The Navy/Marine Corps needs include an improved use rapid, airborne characterization of littoral environments including time-varying coastal topography, littoral bathymetry, sea-level height, land and seafloor sedimentary structures as well as quantification of the influence of turbulence generated at the seafloor boundary layer on vertical mixing and stratification in shallow water outside the surf zone. Undersea Warfare: Conceptualize and perform laboratory and field studies to understand and exploit energy storage and retrieval from the benthic interface and the potential to balance small scale and large scale intermittent power generation with power demand for persistent operation of marine sensors presently powered by batteries. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increases from FY 2019 to FY 2020 is due to the need to provide increasing support for all fleet operations for current and/or emerging systems of research vessels of the U.S. Academic Research Fleet for operations, maintenance, repair and upgrades that enable applied research at sea and provides modeling and analysis for environmental compliance for ONR/NRL field work and active acoustic experiments.					
Title: Marine Mammals and Biology	3.351	3.630	3.482	0.000	3.482

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602435N / *Ocean Wrfghtg Env Applied Res*	**Project (Number/Name)** 0000 / *Ocean Wrfghtg Env Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Description: The Marine Mammals and Biology activity focus is to better understand and characterize the effects of underwater sounds produced by Navy sources (especially sonar) on marine mammals. Efforts include research on integrated ecosystems, effects of sound exposure on marine mammals, and improving the monitoring and detection of marine mammals. The research in this program supports Navy environmental compliance information needs and facilitates acquiring LOAs from NOAA that enable all Navy training and testing operations, and the development of appropriate state-of-the-art mitigation measure. ***FY 2019 Plans:*** Integrated Ecosystem Research: Continue research to understand the patterns and causes of variability in the distribution and abundance of marine mammals over space and time. Continue multidisciplinary approach using tagging, visual surveys, and passive acoustics to collect baseline measures of marine mammal behaviors and distributions relative to environmental features and marine mammal prey fields. Effects of Sound: Continue research on behavioral, physiological (hearing and stress response), and potentially population-level consequences of sound exposure on marine life. Continue research to characterize the causal chain of events leading from sound exposure to "biologically significant" behavioral reactions that might increase risks of population-level effects and/or the potential for stranding. Continue research to develop an understanding of the natural variation of stress markers, better understand and characterize the relationships among hormones or other biomarkers in different matrices and characterize the relationship between the physiological stress response in marine mammals and acoustic exposure. Monitoring and Detection: Continue research to develop and test new and existing technology to detect and classify marine mammals in the marine environment and during periods of low light. Continue the development and testing of new autonomous hardware platforms using passive acoustics and/or IR to detect and classify marine mammals. ***FY 2020 Base Plans:*** Extramural Marine Mammals and Biology - Areas of research include monitoring and detection, integrated ecosystem, and effects of sound on marine mammals. Integrated Ecosystem Research: Further research using animal tagging and passive acoustic monitoring to study behaviors,					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602435N / *Ocean Wrfghtg Env Applied Res*	**Project (Number/Name)** 0000 / *Ocean Wrfghtg Env Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
movement and distribution of marine mammals relative to key environmental properties (biotic and abiotic). Effects of Sound: Conduct research on behavioral effects to potentially population-level consequences of sound exposure on marine life. Initiate research to characterize the gas management and kinetics (stores and use) in marine mammals. Conduct research into the mechanisms that enable marine mammals to dive to deep depths for long durations while mitigating, if not avoiding, health threats. Conduct research to advance our understanding of sound reception mechanisms in mysticetes (large whales) will require a thorough exploration of the anatomy surrounding the ear and the whole head combined with modeling sound propagation through various tissues of whale heads and/or bodies. Conduct research to develop an understanding of the natural variation of stress markers, better understand and characterize acute and chronic effects of the stress response on individuals and populations of marine mammals. Conduct research on potential effects of Navy sources on marine mammal behavior, life functions (e.g. feeding, breeding, migrating), vital rates (e.g. adult survival, reproduction), and population level effects. Understanding the effects of naval activities on species or stocks of marine mammals, including effects on annual rates of recruitment and survival. Monitoring and Detection: Conduct research and development of technology for detection, classification, and localization of marine mammals. Models & Databases: Conduct research to provide tools to support environmental compliance efforts and decision making related to how marine mammals are affected by anthropogenic sounds. Initiate research using increase in funds to characterize and quantify the cumulative effects of multiple stressors on marine mammal populations. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: Marine Meteorology	9.265	9.567	9.908	0.000	9.908
Description: The Marine Meteorology activity develops observing technologies, models, Numerical Weather Prediction (NWP) systems and Tactical Decision Aids (TDA) that describe the atmospheric environment and its impacts on naval sensors and operations. This activity focuses on uniquely marine aspects of atmospheric					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602435N / *Ocean Wrfghtg Env Applied Res*	**Project (Number/Name)** 0000 / *Ocean Wrfghtg Env Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
science such as air-sea interaction, coupled ocean-atmosphere modeling, Electric Magnetic (EM) and Electric Optical (EO) propagation, coastal meteorology, Tropical Cyclone (TC) prediction, and the use of remote sensing to obtain quantitative observations of atmospheric properties. Aspects of the atmospheric environment of particular interest include near-surface phenomena that affect refractivity, marine boundary layer dynamics that affect clouds, rain, visibility and fog, and processes that control TC structure, track, and intensity. Objectives of this activity are improved NWP systems and TDAs that provide NOWCAST and forecast skill at global, regional, and tactical scales for operational support, sensor and system development, and performance prediction. ***FY 2019 Plans:*** Perform field measurements; theoretical analyses; development of data fusion, data assimilation and modeling technologies; increasing knowledge content of data from remote sensing and through-the-sensor systems; exploring dynamical and physical processes, coupled atmosphere/ocean/wave/ice/land processes, atmospheric predictability, and methodologies for probabilistic forecasting and characterization of uncertainty. Studies encompass the design, performance, analysis and underlying theory of field and laboratory experiments and telescoping, global-to-tactical scale numerical simulations specifically designed to understand atmospheric environmental processes and phenomena. These studies include efforts to develop appropriate inversion and other techniques to obtain atmospheric environmental data from airborne and spaceborne sensors. Research is coordinated with operational customers to enable rapid transition of research into operations. Initiate the development of a version of the Navy's regional NWP prediction system (COAMPS) that incorporates new physics and is optimized to provide much more accurate forecasts in the Arctic, particularly for poorly predicted phenomena like polar lows, and couples with ocean and ice forecast models. Battlespace Environments: Perform field measurements; theoretical analyses; development of data fusion, data assimilation and modeling technologies; increasing knowledge content of data from remote sensing and through-the-sensor systems; exploring dynamical and physical processes, coupled atmosphere/ocean/wave/ice/land processes, atmospheric predictability, and methodologies for probabilistic forecasting and characterization of uncertainty. Encompasses the design, performance, analysis and underlying theory of field and laboratory experiments and telescoping, global-to-tactical scale numerical simulations specifically designed to understand atmospheric environmental processes and phenomena. Includes efforts to develop appropriate inversion and other techniques to obtain atmospheric environmental data from airborne and spaceborne sensors. Includes empirical and numerical model development techniques and associated efforts designed to improve atmospheric prediction, diagnose problems and increase the efficiency and accuracy of those models and model systems in a variety of computational environments. Includes efforts to fuse, merge and exploit atmospheric data and					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602435N / *Ocean Wrfghtg Env Applied Res*	**Project (Number/Name)** 0000 / *Ocean Wrfghtg Env Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
create operationally useful information. The research is coordinated with operational customers to enable rapid transition of research into operations. ***FY 2020 Base Plans:*** Perform field measurements; theoretical analyses; development of data assimilation and modeling technologies; increasing knowledge content of data from remote sensing and through-the-sensor systems; improve the representation of dynamical and physical processes, coupled atmosphere/ocean/wave/ice/land processes, atmospheric predictability, and methodologies for probabilistic forecasting and characterization of uncertainty. These studies include efforts to develop appropriate techniques to obtain atmospheric environmental data from airborne and spaceborne sensors. Additional effort is focused on parameters that affect Electric Optical (EO) and Electric Magnetic (EM) propagation in the marine environment. Develop and improve/optimize the Navy's regional Numerical Weather Prediction (NWP) prediction system (COAMPS) by increasing resolution and incorporating new physics and numerical methods to provide much more accurate forecasts, particularly for poorly predicted phenomena like Arctic storms, and coupling with ocean and ice forecast models. Develop and improve tropical cyclone forecast models through improved physics, coupling to the ocean and upper atmosphere, assimilation of new observations, data assimilation methods and novel ensemble methods that quantify forecast uncertainty. Conduct research on a next-generation global NWP model that incorporates efficient numerical methods, variable-resolution grids, improved representation of physics, and that can operate efficiently on future computation systems. The goal is to potentially replace the rectangular nested-grid systems currently in use, and combine global and regional modeling into a unified and more efficient system. Encompasses the design, performance, analysis and underlying theory of field and laboratory experiments and telescoping, global-to-tactical scale numerical simulations specifically designed to understand atmospheric environmental processes and phenomena. Includes efforts to develop appropriate inversion and other techniques to obtain atmospheric environmental data from airborne and space-borne sensors. Includes empirical and numerical model development techniques and associated efforts designed to improve atmospheric prediction, diagnose problems and increase the efficiency and accuracy of those models and model systems in a variety of computational environments. Includes efforts to fuse, merge and exploit atmospheric data and					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602435N / *Ocean Wrfghtg Env Applied Res*	**Project (Number/Name)** 0000 / *Ocean Wrfghtg Env Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
create operationally useful information. The research is coordinated with operational customers to enable rapid transition of research into operations. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: National Oceanographic Partnership Program (NOPP) ***Description:*** This activity focuses on US Navy investments in the National Oceanographic Partnership Program (NOPP). NOPP, established by the US Congress (Public Law 104-201) in Fiscal Year 1997, is a unique collaboration among 15 federal agencies involved in conducting, funding, or utilizing results of ocean research. NOPP's value to the Navy derives from the capacity of the partnership to enable and ensure multi-agency efforts where such collaboration enhances efficiency or effectiveness, and/or reduces costs. NOPP topics address scientific problems that cross-agency missions, fall in gaps between agencies and/or are too large for any one agency to fund itself. ***FY 2019 Plans:*** Further development of an integrated coastal ocean observation system and development of sensors, communications and data acquisition, storage and processing tools required to affect it, modernization of ocean research and observation infrastructure, and marine mammal-related research. Continue applied research activities to include conducting studies to develop an integrated coastal ocean observation system and associated sensors, communications, data acquisition, storage and processing tools. Continue efforts to develop small space-based sensors for littoral oceanographic and atmospheric dynamics research; tools for improved production and application of high resolution sea surface temperature data; and miniaturized, next generation sensors for ocean measurements. ***FY 2020 Base Plans:*** The focus remains on topics that cross agency missions and/or are too large for one agency to address alone; this includes ocean/coastal dynamical process studies, observation and modeling systems, development of sensors, communications and data acquisition, storage and processing tools required to affect it, modernization of ocean research and observation infrastructure, and marine mammal-related research. Conduct of studies focused on model verification, constraint of boundary conditions and fluxes of mass, heat and momentum across them (air-sea, deep ocean-seabed, land-sea), and responses to storm and/or persistent forcing are anticipated.	8.470	8.781	8.742	0.000	8.742

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602435N / *Ocean Wrfghtg Env Applied Res*	**Project (Number/Name)** 0000 / *Ocean Wrfghtg Env Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Expand the development and utilization of small space-based sensors for oceanographic and atmospheric dynamics research; and miniaturized, low-power, next generation sensors for ocean measurements. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: Ocean Acoustics ***Description:*** The Ocean Acoustics activity is dedicated to the determination of the impact of the natural ocean environment on acoustic wave phenomena in support of naval undersea warfare and underwater force protection operations. This activity studies underwater acoustic propagation, scattering from ocean boundaries, and ambient noise issues that impact the development and employment of acoustic systems. The littoral zone has been the ocean environment of greatest interest. Aspects of this environment, that greatly impact underwater acoustic systems, are the shallow water, the consequent closeness and physical significance of the ocean bottom, and the complexities inherent to rapid changes of the ocean structure. The objectives of this program are met through measuring, analyzing, modeling and simulating, and exploiting ocean acoustic factors to gain advantage over potential adversaries using undersea acoustic systems. Results of this activity support acoustic sensor and system development, performance prediction, and tactical decision aids. This Activity will also focuses on efforts addressing research needs identified by Task Force Ocean that will enable tactical maneuver for the future submarine force. The efforts funded by this Program Element (PE) fall generally into two topic areas: Analysis and understanding of the impact of environmental conditions on Large Vertical Aperture (LVA) Array sonar data, and the development of reduced order ocean-acoustic models to enable environmental awareness and prediction on forward platforms. ***FY 2019 Plans:*** Continue applied research to provide the Warfighter with improved Anti-Submarine Warfare (ASW) performance assessment models and tactical decision aids to plan ASW operations, evaluate effectiveness of ASW systems, and enable environmental adaptive system control. Continue to provide ASW sensor and system performance models, realistic simulations, and measures of effectiveness that incorporate and exploit critical environmental knowledge requires coupling ocean dynamics and acoustics, ambient noise characterization in the littorals, acoustic and optical scattering and propagation characterization, through-the-sensor measurement techniques	2.026	2.074	19.052	0.000	19.052

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602435N / *Ocean Wrfghtg Env Applied Res*	**Project (Number/Name)** 0000 / *Ocean Wrfghtg Env Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total

for in situ environmental parameters, measurement and prediction of uncertainty, and development of tactical decision tools. Continue efforts of applied research to enhance passive sonar performance capability in the Arctic environment by developing a better passive sonar performance prediction model and new acoustic ice-characterization methods.

FY 2020 Base Plans:

Conduct research efforts to enable environmental awareness and tactical exploitation of the environment by forward naval platforms. Activities will include the development of technologies and algorithms to incorporate in situ environmental sensing into an on-scene environmental characterization capability, inversion of sensor data to infer the local environment, and the development of capabilities to exploit the ocean environment for tactical advantage. Research efforts are informed by the outcome of the Tactical Oceanography Symposia series conducted by the Office of Naval Research, which involve academic researchers, industry partners, and the operational Navy.

Conduct applied research to provide the Warfighter with improved Anti-Submarine Warfare (ASW) performance assessment models and tactical decision aids to plan ASW operations, evaluate effectiveness of ASW systems, and
enable environmental adaptive system control. The capability to provide ASW sensor and system performance models,
realistic simulations, and measures of effectiveness that incorporate and exploit critical environmental knowledge requires coupling ocean dynamics and acoustics, ambient noise characterization in the littorals, acoustic and optical scattering and propagation characterization, through-the-sensor measurement techniques for in situ environmental parameters,measurement and prediction of uncertainty, and development of tactical decision tools. Efforts include continuation of applied research to enhance passive sonar performance capability in the Arctic environment by developing a better passive sonar performance prediction model and new acoustic ice-characterization methods.

FY 2020 OCO Plans:

N/A

FY 2019 to FY 2020 Increase/Decrease Statement:

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602435N / *Ocean Wrfghtg Env Applied Res*	**Project (Number/Name)** 0000 / *Ocean Wrfghtg Env Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
The increase from FY 2019 to FY 2020 is due to the initiation of the Task Force Ocean project to gain a better understanding on the oceans, especially in the Artic, with respect to global prediction based on the outcome of the Chief Naval Operations Task Force Ocean working groups and recommended courses of action.					
Title: Physical Oceanography ***Description:*** The goal of the Physical Oceanography activity is to develop knowledge of the physics of the ocean within the battlespace environment to enable tactical naval use and exploitation of the battlespace. This is achieved through the development of predictive models of the water mass structure, waves, currents, and air-sea interactions and developing measurement/observation technology. Other applications utilize knowledge of the interaction of the water column hydrodynamics and the acoustics to predict the undersea transmission characteristics and sources of uncertainty in these statistics. Utilizing knowledge of the ocean surface physics, the physical oceanography program seeks to exploit the combination of remotely sensed data, in-situ data, and adaptively sampled data to optimize predictions of ocean currents and water column structure. These predictions, custom databases, adaptive sampling schemes and data programs serve Anti-Submarine Warfare, Naval Special Warfare, and Mine and Expeditionary Warfare. This Program requires field research that involves participation in Navy Environmental planning efforts including environmental planning documents (Environmental Impact Statements). The use of active acoustic transmissions requires modeling of the acoustic effects of sound on marine life. ***FY 2019 Plans:*** Conduct applied oceanographic research including field campaigns to study ocean processes and dynamics, ocean model development, and data assimilation from the open ocean to the nearshore environments. Data assimilation development extends use of coupled modeling approaches to include air-ice-wave-ocean-land models. Studies develop new or enhance existing shipboard, in-situ, airborne, and spaceborne sensors and appropriate inversion and "through the sensor" techniques to obtain physical oceanographic environmental data, and to fuse and exploit oceanographic data to create operationally useful information. Efforts continue to develop and test the Remote Ocean Sampling System for air-sea surface flux sampling as well as developing advanced autonomy for operations of gliders in extreme environments. Additional efforts develop ocean drifters with stable salinity sensors and high resolution turbulence sensors. Continue the effort to develop a capability to estimate global ocean forecast uncertainty from ensembles which will enable risk assessment with skill out to 30 days, providing the real-time assessment of environmental uncertainty anywhere on demand and risk	10.258	10.927	11.158	0.000	11.158

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602435N / *Ocean Wrfghtg Env Applied Res*	**Project (Number/Name)** 0000 / *Ocean Wrfghtg Env Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
analysis products that can be used as inputs to existing decision support tools such as risk quantification and mission planning. Continue the effort to develop a new capability for accurate and rapid characterization of the local ocean battlespace utilizing the ability of gliders to work in coordinated teams and 4-dimensional variation assimilation to maximize impact of the glider data in a high-resolution local forecast model for more accurate ocean predictions Battlespace Environments: A program including field research on ocean processes and dynamics, ocean model development, and data assimilation from the open ocean to the nearshore and riverine environments is directed towards model system development and analysis. Model and data assimilation development is extending to the field of coupled models including air-ice-wave-ocean-land models. Encompasses the design, analysis and underlying theory of field and laboratory experiments designed to understand ocean environmental processes and phenomena. It includes model development to improve ocean environmental predictive capabilities, through improved physical characterization, diagnosis, efficiency and accuracy of these models in a variety of computational environments. Also includes efforts to develop new or enhance existing shipboard, in-situ, airborne, and spaceborne sensors and appropriate inversion and "through the sensor" techniques to obtain physical oceanographic environmental data. Includes effort to fuse and exploit oceanographic data to create operationally useful information. The research is coordinated with operational customers to enable its rapid transition into operational systems. ***FY 2020 Base Plans:*** Conduct applied oceanographic research including field campaigns to study ocean processes and dynamics, ocean model development, and data assimilation from the open ocean to the nearshore environments. Data assimilation development extends use of coupled modeling approaches to include air-ice-wave-ocean-land models. Studies develop new or enhance existing shipboard, in-situ, airborne, and space borne sensors and appropriate inversion and "through the sensor" techniques to obtain physical oceanographic environmental data, and to fuse and exploit oceanographic data to create operationally useful information. The testing of the Remote Ocean Sampling System for air-sea surface flux sampling will be completed following the deployments in the North Atlantic. Efforts to develop advanced autonomy for the operations of gliders in extreme environments is also completed. Testing of gliders with turbulence sensors, Unmanned Underwater Vehicles (UUVs) with turbulence sensors will continue. Additional efforts develop ocean drifters with stable salinity sensors and high resolution turbulence sensors will continue.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602435N / *Ocean Wrfghtg Env Applied Res*	**Project (Number/Name)** 0000 / *Ocean Wrfghtg Env Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Continue the effort to develop a capability to estimate global ocean forecast uncertainty from ensembles which will enable risk assessment with skill out to 30 days, providing the real-time assessment of environmental uncertainty anywhere on demand and risk analysis products that can be used as inputs to existing decision support tools such as risk quantification and mission planning. Continue the effort to develop a new capability for accurate and rapid characterization of the local ocean battlespace utilizing the ability of gliders to work in coordinated teams and 4-dimensional variation assimilation to maximize impact of the glider data in a high-resolution local forecast model for more accurate ocean predictions. Testing of ocean instrumentation that features energy harvesting will be initiated. The TOPSIDE software of the data server module will be tested with ocean data sets that are publically available and cloud computing and serving will be evaluated and tested. Battlespace Environments: A program including field research on ocean processes and dynamics, ocean model development, and data assimilation from the open ocean to the nearshore and riverine environments is directed towards model system development and analysis. Model and data assimilation development is extending to the field of coupled models including air-ice-wave-ocean-land models. Encompasses the design, analysis and underlying theory of field and laboratory experiments designed to understand ocean environmental processes and phenomena. It includes model development to improve ocean environmental predictive capabilities, through improved physical characterization, diagnosis, efficiency and accuracy of these models in a variety of computational environments. Also includes efforts to develop new or enhance existing shipboard, in-situ, airborne, and spaceborne sensors and appropriate inversion and "through the sensor" techniques to obtain physical oceanographic environmental data. Includes effort to fuse and exploit oceanographic data to create operationally useful information. The research is coordinated with operational customers to enable its rapid transition into operational systems. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Accomplishments/Planned Programs Subtotals	41.145	42.998	63.894	0.000	63.894

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602435N / *Ocean Wrfghtg Env Applied Res*	**Project (Number/Name)** 0000 / *Ocean Wrfghtg Env Applied Res*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

All Science and Technology model improvements undergo a rigorous validation verification and evaluation against quantifiable metrics before being accepted for transition into operations. In Marine Meteorology, for example, typical improvements over the past decade have amounted to a gain in skill of one forecast-day (i.e., the 4-day forecast is now as skillful as the 3-day forecast of a decade ago), and tropical cyclone forecast track error has been reduced by 50%. It is expected that future increases in skill will continue at or above this pace.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602435N / *Ocean Wrfghtg Env Applied Res*	Project (Number/Name) 9999 / *Congressional Adds*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	31.385	47.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	78.385

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Program Increase ***FY 2018 Accomplishments:*** Additional funds will enhance new Task Force Ocean programs to enable tactical exploitation of the ocean environment. ***FY 2019 Plans:*** N/A	7.243	0.000
Congressional Add: AGOR Mid-life Refit ***FY 2018 Accomplishments:*** Additional funds provided in the FY18 Appropriation for the AGOR 23 Class Mid-Life Refit supports the replacement or upgrade of the Bow Thruster propulsion systems on the AGOR 23 Class vessels. AGOR 23 R/V Thomas G Thompson completed its major, mid-life refit overhaul, shakedown and testing, and re-entered the U.S. Academic Research Fleet in support of Navy oceanographic research objectives. ***FY 2019 Plans:*** N/A	19.314	0.000
Congressional Add: Naval Special Warfare Maritime Science and Technology ***FY 2018 Accomplishments:*** Funds supported applied oceanographic research to exploit ocean currents, water surface and seafloor roughness, and ocean optoacoustical properties, among other phenomena, to enhance underwater vehicle and diver operations. ***FY 2019 Plans:*** N/A	4.828	0.000
Congressional Add: Naval Special Warfare	0.000	10.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602435N / *Ocean Wrfghtg Env Applied Res*	**Project (Number/Name)** 9999 / *Congressional Adds*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
FY 2018 Accomplishments: N/A ***FY 2019 Plans:*** Funds supported applied oceanographic research to exploit ocean currents, water surface and seafloor roughness, and ocean optoacoustical properties, among other phenomena, to enhance underwater vehicle and diver operations.		
Congressional Add: Task Force Ocean ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Exploration of analytic techniques linking physical oceanographic variability with acoustic propagation, including field efforts to collect relevant data sets. The development and use of artificial intelligence and machine learning techniques for large ocean and acoustic data sets. Through-the-sensor environmental characterization, including assimilation into nested local environmental prediction models. Exploration and development of advanced signal processing techniques that incorporate local ocean structure, including ambient noise characterization	0.000	10.000
Congressional Add: Acoustics Research ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Research in applied acoustics, advanced sensor capabilities and better undersea environment data to directly characterizing the physical environment and provide information to monitor ecosystem health, impacts, and change. This investments will support the potential for improved performance of US Navy soar systems for surveillance and reconnaissance.	0.000	2.000
Congressional Add: Multi-Modal Detection Research ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Research in non-acoustic detection, tracking, localization, and identification of underwater threats.	0.000	10.000
Congressional Add: Persistent Maritime Surveillance ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Conduct supplemental study and research supporting advances in technologies to enable Persistent Maritime Surveillance capabilities.	0.000	15.000
Congressional Adds Subtotals	31.385	47.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602435N / *Ocean Wrfghtg Env Applied Res*	**Project (Number/Name)** 9999 / *Congressional Adds*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other Projects.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602651M *I JT Non-Lethal Wpns Applied Res*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	6.230	6.299	6.346	-	6.346	6.343	6.468	6.600	6.732	Continuing	Continuing
0000: *JT Non-Lethal Wpns Applied Res*	0.000	6.230	6.299	6.346	-	6.346	6.343	6.468	6.600	6.732	Continuing	Continuing

A. Mission Description and Budget Item Justification

The DoD Non-Lethal Weapons Program was established by the FY96 National Defense Authorization Act. The Office of the Secretary of Defense designated the Commandant of the Marine Corps (CMC) as the DoD NLW Executive Agent (EA). The EA exercises centralized responsibility for joint research and development of non-lethal weapons and technology through the Joint Non-Lethal Weapons Program (JNLWP). The Office of the Under Secretary of Defense for Acquisition and Sustainment (A&S) serves as the OSD Principal Staff Assistant and oversees, in consultation with the Under Secretary of Defense for Policy, the DoD NLW Executive Agent.

The efforts described in this Program Element (PE) reflect science and technology (S&T) investment decisions by the Joint Non-Lethal Weapons (NLW) Integrated Product Team, a multi-service flag level corporate board that provides executive oversight and management for the JNLWP for the CMC. This direction is based on the requirements and capabilities sought by the Services and the Coast Guard, as identified in the DoD's Non-Lethal Weapons Joint Capabilities Based Assessment Document. This coordinated joint S&T development approach addresses mutual capability gaps and assures the most relevant non-lethal technologies, capabilities and equipment are provided to the operating forces while eliminating duplicative service S&T investment. These applied research initiatives feed non-lethal capabilities which directly support the National Defense Strategy (NDS) objective of strategic competition by providing options to the joint force in pursuit of national objectives in legal or policy constrained scenarios, as well as complementing the use of lethal effects in complex combat scenarios, for example, in urban environments with large civilian populations. Ongoing NLW studies, analyses and exercise efforts with NATO and Allies also support NDS objectives to strengthen alliances and partnerships. Resulting capabilities facilitate a fully integrated non-lethal competency as a complement to lethal firepower, providing force application options for below lethal threshold engagements.

This program funds the applied research, study, assessment, and demonstration of technologies that could provide a non-lethal capability or target effect. Investment areas include applied research related to: non-lethal directed energy weapons (lasers, millimeter wave and high power microwave) for counter-personnel and counter-materiel missions; non-lethal acoustic and optical technologies; advanced non-lethal materials (including materials for vehicle/vessel stopping and counter-facility applications); associated human effects and effectiveness for new non-lethal stimuli; injury potential and effectiveness of directed energy, electric incapacitation, ocular, and acoustic based non-lethal technologies; and developing models of crowd behavior and dynamics.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy					Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*			R-1 Program Element (Number/Name) PE 0602651M *I JT Non-Lethal Wpns Applied Res*		
B. Program Change Summary ($ in Millions)	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**
Previous President's Budget	6.425	6.349	6.346	-	6.346
Current President's Budget	6.230	6.299	6.346	-	6.346
Total Adjustments	-0.195	-0.050	0.000	-	0.000
• Congressional General Reductions	-	-0.050			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.162	0.000			
• Rate/Misc Adjustments	0.001	0.000	0.000	-	0.000
• Congressional General Reductions Adjustments	-0.034	-	-	-	-

Change Summary Explanation

Technical: Not applicable.

Schedule: Not applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602651M / *JT Non-Lethal Wpns Applied Res*	Project (Number/Name) 0000 / *JT Non-Lethal Wpns Applied Res*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *JT Non-Lethal Wpns Applied Res*	0.000	6.230	6.299	6.346	-	6.346	6.343	6.468	6.600	6.732	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project funds the applied research, study, assessment, and demonstration of technologies that could provide a non-lethal capability or target effect. Investment areas include applied research related to: non-lethal directed energy weapons (lasers, millimeter wave and high power microwave) for counter-personnel and counter-materiel missions; non-lethal acoustic and optical technologies; advanced non-lethal materials (including materials for vehicle/vessel stopping and counter-facility applications); associated human effects and effectiveness for new non-lethal stimuli; injury potential and effectiveness of directed energy, electric stun, ocular, and acoustic based non-lethal technologies; and developing models of crowd behavior and dynamics.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: (U) JOINT NON-LETHAL WEAPONS	6.230	6.299	6.346	0.000	6.346
FY 2019 Plans: Continue research and investigation of emergent technologies and effects with the potential to address non-lethal counter-personnel and counter-materiel capability gaps. Some examples of counter-personnel research include non-lethal weapon (NLW) effectiveness and behavioral research studies, feasibility and conceptual design studies for next-generation electro-muscular incapacitation and directed energy technologies (e.g., lasers, millimeter-waves) suitable for extended range applications and to achieve longer duration of effect. Investigation and initial design of component high power microwave system technologies and advanced materials for counter-materiel applications will continue in order to enable reduced system sizes, increased energy efficiency, improved performance, and increased delivery and employment options. Continue applied research to characterize non-lethal phenomena and assess target human effects and weapon effectiveness, including development of dose response and injury correlates for new NLW technologies. Initiate exploration of new non-lethal effects and evaluation of innovative applications of existing technologies to address future non-lethal capability needs. Transition results to higher levels of technology development and demonstration as feasibility is determined.					
FY 2020 Base Plans: Conduct research and investigation of emergent technologies and effects with the potential to address non-lethal counter-personnel and counter-materiel capability gaps. Some examples of counter-personnel research include optimizing known NLW effectiveness and discovery of new human target behavioral effects which mitigate these Joint Requirements Oversight Counsel-approved joint non-lethal effects capability-gaps. Other examples are					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602651M / *JT Non-Lethal Wpns Applied Res*	**Project (Number/Name)** 0000 / *JT Non-Lethal Wpns Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
the assessment and study of new NLW technologies related to: (1) increasing the range of current NLWs; (2) increasing their duration of effect; and (3) increasing the volume of fire associated with NLWs. This includes developing longer range, more compact: (1) NL sound and light devices; (2) smaller, lighter, and more power efficient high power microwave systems; and (3) developing new non-lethal laser induced plasma weapons for long range counter-personnel and counter-materiel applications. The objective is to further reduce non-lethal directed energy weapon system size, weight, power consumption, thermal cooling requirements and overall system cost while increasing counter-personnel and counter-materiel capabilities. Continue applied research to characterize new non-lethal phenomena and assess new target human effects and weapon effectiveness, including development of dose response and injury correlates for new NLW technologies. Continue concept exploration of novel NLW capabilities for integration into future escalation of force platforms. Transition results to higher levels of technology development and demonstration as feasibility is determined. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Accomplishments/Planned Programs Subtotals	6.230	6.299	6.346	0.000	6.346

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

The primary objective of this Program Element is the development of technologies that lead to the next-generation of Non-Lethal Weapons. The program consists of a collection of projects that range from studies and analyses to the development and evaluation of feasibility demonstration models. Individual project metrics reflect the technical goals of each specific project. Typical metrics include both the effectiveness of the technology, human effects and effectiveness, and potential for compliance with policy and legislation. Overarching considerations include the advancement of related Technology Readiness Levels and Human Effects Readiness Levels, the degree to which project investments are leveraged with other performers, reduction in life cycle cost upon application of the technology, and the identification of opportunities to transition technology to higher categories of development.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602747N *I Undersea Warfare Applied Res*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	59.644	78.049	57.075	-	57.075	57.197	58.334	59.529	60.724	Continuing	Continuing
0000: *Undersea Warfare Applied Res*	0.000	54.816	58.049	57.075	-	57.075	57.197	58.334	59.529	60.724	Continuing	Continuing
9999: *Congressional Adds*	0.000	4.828	20.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	24.828

A. Mission Description and Budget Item Justification

This Program Element (PE) funds applied research efforts in undersea target detection, classification, localization, tracking, and neutralization. Technologies being developed within this PE are aimed at enabling Sea Shield, one of the core operational concepts detailed in the Naval Transformational Roadmap. Associated efforts focus on new Anti-Submarine Warfare (ASW) operational concepts that promise to improve wide-area surveillance, detection, localization, tracking, and attack capabilities against quiet adversary submarines operating in noisy and cluttered shallow water environments. Related efforts are aimed at leveraging technologies that will protect the country's current capital investment in surveillance, submarine, surface ship, and air ASW assets. Research focused on understanding the impacts on marine mammals of manmade underwater sound is also conducted in the Program Element , as well as continuing support to research vessels of the U.S. Academic Research Fleet for operations and maintenance that enable applied research at sea.

The activities described in this program element PE address future Navy and Marine Corps capabilities needed to maintain maritime superiority and ensure national security. They are based on input from Naval Research Enterprise stakeholders (including the Naval enterprises, the combatant commands, OPNAV and Headquarters Marine Corps) and are designed to exploit breakthroughs in science and technology in order to deliver maximum warfighting benefit to our sailors and marines. These efforts are aligned with shared priorities throughout the whole of RDT&E in order to quickly advance new capabilities from discovery to deployment across the warfighting domains.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602747N *I Undersea Warfare Applied Res*

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	56.094	58.049	57.324	-	57.324
Current President's Budget	59.644	78.049	57.075	-	57.075
Total Adjustments	3.550	20.000	-0.249	-	-0.249
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	20.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.450	0.000			
• Program Adjustments	0.000	0.000	-0.249	-	-0.249
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
• Congressional Add Adjustments	5.000	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Program Increase*	4.828	20.000
Congressional Add Subtotals for Project: 9999	4.828	20.000
Congressional Add Totals for all Projects	4.828	20.000

Change Summary Explanation

Schedule: Not applicable.

Technical: Not applicable

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602747N / *Undersea Warfare Applied Res*	Project (Number/Name) 0000 / *Undersea Warfare Applied Res*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *Undersea Warfare Applied Res*	0.000	54.816	58.049	57.075	-	57.075	57.197	58.334	59.529	60.724	Continuing	Continuing

A. Mission Description and Budget Item Justification

This PE funds applied research efforts in undersea target detection, classification, localization, tracking, and neutralization. Technologies being developed within this project are aimed at enabling Sea Shield which is one of the core operational concepts detailed in the Naval Transformational Roadmap. Associated efforts focus on new ASW operational concepts that promise to improve wide-area surveillance, detection, localization, tracking, and attack capabilities against quiet adversary submarines operating in noisy and cluttered shallow water environments. Related efforts are aimed at leveraging technologies that will protect the country's current capital investment in surveillance, submarine, surface ship, and air ASW assets.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: ANTI-SUBMARINE WARFARE (ASW) DISTRIBUTED SEARCH	14.974	15.154	15.455	0.000	15.455
Description: ASW Distributed Search focuses on the development of technologies for the non-covert tactical search for undersea targets ranging from hours to weeks, using automated sensor systems deployed around operating areas, including along key transit routes to protect naval/maritime forces, around temporarily fixed sea base regions and naval force operating areas, or around fixed defensive regions and areas of interest, such as key US/Allied ports. "Non-covert" implies availability of airborne assets for sensor deployment (although other means may also be used), and the ability to employ active sonar along with passive and non-acoustic methods. "Search" is conducted in concentrated areas, typically exploiting cues received from surveillance systems. The submarine target must be detected beyond its weapons release range. The objective is to develop rapidly deployable systems employing automated detection and classification capabilities for use in both shallow and deep water operating environments. Distributed Search supports the ASW protected passage Maritime Shield operational constructs. Related efforts include the development of distributed systems employing optimization as well as active acoustic sensing and processing techniques, navy-unique transduction and underwater networking technology. Efforts also include the development of Unmanned Undersea Vehicle-based and affordable off-board deployable sensing systems employing persistent detection concepts and components. These efforts provide an extended reach of organic platform-based systems through the use of new sensor concepts, improved materials for advanced sensors, optimized deployment, employment, and automated operation of distributed sensor fields. The cornerstone of Distributed Search is the development of rapidly deployable, long-endurance active sensors with automated processing suitable for use in a wide variety of operational environments.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602747N / *Undersea Warfare Applied Res*	**Project (Number/Name)** 0000 / *Undersea Warfare Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
FY 2019 Plans: Undersea Warfare Applied research focused on technologies that enable both platform-based and off-board systems to detect and classify the ultra-quiet, low-Doppler submarine threat in complex operating environments. The capability to provide non-covert ASW tactical search for both shallow and deep water operational areas against all submarine threats requires improved sensor technology to extend the capabilities of platform-based systems; innovative sensor technology for off-board and rapidly deployable systems; characterization of and signal processing to control reverberation, clutter, and noise; characterization of target radiation and scattering physics for all threat submarines; physics-based detection and classification algorithms with automation where possible; and knowledge and exploitation of the complex operational environment. Continue signal processing-related research which focuses on multistatic active sonar concepts that operate in convergence zone environments, high duty cycle active sonar, and developing concepts for next-generation active sonar system automation. Undersea Warfare Conceptualize and perform laboratory measurements, field measurements, and theoretical/numerical analysis focused on technologies that enable both platform-based and off-board systems to detect and classify the ultra-quiet, low-Doppler submarine threat in complex operating environments such as: advancing sensing, onboard processing/decision making, and information sharing capabilities to enable multi-static ASW using multiple autonomous, coordinated and cooperating AUVs; the development of a new kind of underwater chemical sound source; and efforts that capitalize on structural acoustic features of UUVs and advance sonar design, sensing, and processing/decision making to enable high performance detection and classification of adversarial UUVs.					
FY 2020 Base Plans: Undersea Warfare Applied research is focused on technologies that enable both platform-based and off-board systems to detect and classify the ultra-quiet, low-Doppler submarine threat in complex operating environments. The capability to provide non-covert Anti-Submarine Warfare (ASW) tactical search for both shallow and deep water operational areas against all submarine threats requires improved sensor technology to extend the capabilities of platform-based systems; innovative sensor technology for off-board and rapidly deployable systems; characterization of and signal processing to control reverberation, clutter, and noise; characterization of target radiation and scattering physics for all threat submarines; physics-based detection and classification algorithms with automation where possible; and knowledge and exploitation of the complex operational environment. Continue sensor development and signal processing-related research which focuses on multistatic active sonar concepts that operate in convergence zone environments, high duty cycle active					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
sonar, and developing concepts for next-generation active sonar system automation. Initiate non-acoustic, orthogonal concepts that complement and augment active sonar concepts. Undersea Warfare Conceptualize and perform laboratory measurements, field measurements, and theoretical/numerical analysis focused on technologies that enable both platform-based and off-board systems to detect and classify the ultra-quiet, low-Doppler submarine threats in complex operating environments such as: advancing sensing, onboard processing/decision making, and information sharing capabilities to enable multi-static ASW using multiple autonomous, coordinated and cooperating autonomous underwater vehicles (AUVs); the development of a new types of underwater sound sources; and efforts that capitalize on structural acoustic features of unmanned underwater vehicles (UUVs) and advance sonar design, sensing, and processing/decision making to enable high performance detection and classification of adversarial UUVs. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: ANTI-SUBMARINE WARFARE (ASW) PRECISION LOCALIZATION	3.225	3.544	3.468	0.000	3.468
Description: Precision Localization focuses on the development and demonstration of technologies which use information from surveillance or search systems to determine an area of uncertainty (AOU) relative to target range, bearing, and depth adequate to handoff to an attack system. Precision Localization employs non-acoustic techniques such as magnetic and optical sensing to highly localize submerged threats. The objective is to increase magnetic sensor range and robustness, enable deployment on Unmanned Air Vehicles (UAVs), and increase optical sensing search rates. Efforts include the development of non-traditional tracking and advanced magnetic and electric field sensors and processing. These technologies will provide a decreased AOU size thus enabling the effective use of smaller, more versatile torpedoes as well as increased performance gain in detection, targeting, tracking/trailing, and homing via target acquisition and covert prosecution. ***FY 2019 Plans:*** Continue focus on Magnetic and Electric Field Sensing applied research related to critical S&T for Precision Localization using magnetic and electric field sensing technologies. Execute research into novel methods to develop smaller and power efficient, high performance magnetic and electric field sensors. Pursue research					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602747N / *Undersea Warfare Applied Res*	**Project (Number/Name)** 0000 / *Undersea Warfare Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
on advanced concepts for processing arrays of independent sensors to create adaptive magnetic and electric field sensor systems. Expand research to include remote methods of sensing magnetic fields. Optical Sensing will conduct basic research related to critical S&T for Precision Localization using optical sensing technologies. Execute research to better exploit the information capacity available in photonic systems toward development of higher performance optical sensors. Pursue information theoretic optical sampling and telemetry characteristics to better support sensor performance and data integrity. Extend the effectiveness that photonic sensor operate across the air-water interface. Extend the distance optical sensors can effectively operate within the water column. ***FY 2020 Base Plans:*** Shift focus from classical magnetic and electric field sensing toward other modalities and sampling approaches. Investigate alternative methods for Precision Localization leveraging magnetic and electric field sensing technologies and incorporating alternative technologies and approaches. Execute research into novel methods to develop smaller and power efficient, high performance magnetic, electric field and novel sensors. Pursue research on advanced concepts for processing arrays of independent sensors to create adaptive information theoretic sensor systems. Continue research into remote methods of sensing target signatures. Expand Optical Sensing research related to critical Science and Technology (S&T) for Precision Localization. Execute research to better exploit the information capacity available in photonic systems toward development of higher performance optical sensors. Pursue information theoretic optical sampling and telemetry characteristics to better support sensor performance and data integrity. Extend the effectiveness that photonic sensors operate across the air-water interface. Extend the distance optical sensors can effectively operate within the water column. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: ANTI-SUBMARINE WARFARE (ASW) SURVEILLANCE	21.117	22.980	22.288	0.000	22.288
Description: ASW Surveillance focuses on dramatically improving detection, classification, and localization capabilities in large ocean areas relative to the capabilities of legacy ASW surveillance systems. The related technologies support the conduct of covert, wide-area surveillance ranging from one day to six months. The objectives are to develop and demonstrate technologies that provide clandestine indications and warnings in far forward and contested operating areas, and in complex operational environments against all submarine threats,					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
including new threats with unknown target signatures and tactics. Covertness implies use of non-observable platforms and/or deployed automated sensors employing passive sonar, or other non-detectable methods. The surveillance process includes initial detection and classification. Efforts include the development of Unmanned Undersea Vehicle-based and affordable, off-board deployable sensing systems employing a wide variety of surveillance concepts and components. These efforts focus on alternative detection phenomena, vector/tensor sensors, automated acoustic processing, more compact and longer lasting power sources, and high bandwidth, acoustic communications links. ***FY 2019 Plans:*** Undersea Warfare will continue applied research focused on technologies that enable detection and classification of ultra-quiet, low-Doppler submarines in complex operating environments. It emphasizes developments leading to non-platform-based and clandestine systems. The capability to provide ASW clandestine indications and warnings in far-forward and contested areas against all submarine threats requires new sensor concepts to provide improved performance in smaller packages; automated passive acoustic and non-acoustic detection and classification algorithms to eliminate the dependence on traditional ASW platforms; novel power sources and power-harvesting; underwater communications; networking of distributed autonomous sensors; and knowledge and exploitation of the complex operational environment. Conducting signal processing related research that focuses on combining information from multiple arrays in a distributed field that exploit new acoustic signatures, improve detection of weak acoustic sources obscured by clutter, and new sensor and signal processing concepts that exploit underwater acoustic propagation physics to improve the detection of weak acoustic sources in high clutter environments. Continuing support to research vessels of the U.S. Academic Research Fleet for operations and maintenance that enable science at sea. Undersea Warfare Conceptualize and perform laboratory measurements, field measurements, and theoretical/numerical analysis leading to non-platform-based and clandestine systems to provide ASW clandestine indications and warnings in far-forward and contested areas such as: new sensor concepts to provide improved performance in smaller packages; automated passive acoustic and non-acoustic detection and classification algorithms to eliminate the dependence on traditional ASW platforms; undersea communications; secure and robust networking of distributed autonomous sensors; and knowledge and exploitation of the complex operational environment. ***FY 2020 Base Plans:***					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Complete Signal processing related research that focuses on combining information from multiple arrays in a distributed field that exploit new acoustic signatures, improve detection of weak acoustic sources obscured by clutter, and new sensor and signal processing concepts that exploit underwater acoustic propagation physics to improve the detection of weak acoustic sources in high clutter environments. Initiate signal processing related research to develop artificial intelligence technology providing optimized sonar system line-ups that adjust themselves in real time to the current undersea environment. Begin to investigate applicable non-acoustic methods of detection and classification of ultra-quiet, low-Doppler submarines in complex operating environments. Laboratory measurements, field measurements, and theoretical/numerical analysis leading to non-platform-based and clandestine systems to provide ASW clandestine indications and warnings in far-forward and contested areas such as: new sensor concepts to provide improved performance in smaller packages; automated passive acoustic and non-acoustic detection and classification algorithms; undersea communications; acoustically quiet UUV propulsion; and knowledge and exploitation of the complex operational environment. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: MARINE MAMMALS ***Description:*** The Marine Mammals and Biology program focus is to better understand and characterize the effects of underwater sounds produced by Navy sources (especially sonar) on marine mammals. Efforts include research on integrated ecosystems, effects of sound exposure on marine mammals, and improving the monitoring and detection of marine mammals. The research in this program supports Navy environmental compliance information needs and facilitates acquiring LOAs from NOAA that enable all Navy training and testing operations, and the development of appropriate state-of-the-art mitigation measure. The marine mammals research conducted in this Program Element (PE) represents part of a total effort executed in coordination with complementary research performed in PE 0602435N Ocean Warfighting Environment Applied Research.	2.459	2.519	2.464	0.000	2.464

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
This Activity has been created specifically to address the work associated with determining and mitigating the effects on the behavior of marine mammals of manmade sound transmitted underwater. ***FY 2019 Plans:*** Integrated Ecosystem Research: Further research using animal tagging and passive acoustic monitoring to study behaviors, movement and distribution of marine mammals relative to key environmental properties (biotic and abiotic). Effects of Sound: Continue research on behavioral effects to potentially population-level consequences of sound exposure on marine life. Initiate research to characterize the gas management and kinetics (stores and use) in marine mammals. Continue research into the mechanisms that enable marine mammals to dive to deep depths for long durations while mitigating, if not avoiding, health threats. Continue research to advance our understanding of sound reception mechanisms in mysticetes (large whales) will require a thorough exploration of the anatomy surrounding the ear and the whole head combined with modeling sound propagation through various tissues of whale heads and/or bodies. Continue research to develop an understanding of the natural variation of stress markers, better understand and characterize acute and chronic effects of the stress response on individuals and populations of marine mammals. Continue research on potential effects of Navy sources on marine mammal behavior, life functions (e.g. feeding, breeding, migrating), vital rates (e.g. adult survival, reproduction), and population level effects. Understanding the effects of naval activities on species or stocks of marine mammals, including effects on annual rates of recruitment and survival. Monitoring and Detection: Continue research and development of technology for detection, classification, and localization of marine mammals. Continue the development and testing of new autonomous hardware platforms using technology to detect and classify marine mammals using a variety of fixed, towed, floating, and profiling platforms. Models & Databases: Continue research to provide tools to support environmental compliance efforts and decision-making related to how marine mammals are affected by anthropogenic sounds. ***FY 2020 Base Plans:*** Extramural Marine Mammals and Biology - Areas of research include monitoring and detection, integrated ecosystem, and effects of sound on marine mammals. Integrated Ecosystem Research: Further research using animal tagging and passive acoustic monitoring to study behaviors, movement and distribution of marine mammals relative to key environmental properties (biotic and abiotic).					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Effects of Sound: Conduct research on behavioral effects to potentially population-level consequences of sound exposure on marine life. Initiate research to characterize the gas management and kinetics (stores and use) in marine mammals. Conduct research into the mechanisms that enable marine mammals to dive to deep depths for long durations while mitigating, if not avoiding, health threats. Conduct research to advance our understanding of sound reception mechanisms in mysticetes (large whales) will require a thorough exploration of the anatomy surrounding the ear and the whole head combined with modeling sound propagation through various tissues of whale heads and/or bodies. Continue research to develop an understanding of the natural variation of stress markers, better understand and characterize acute and chronic effects of the stress response on individuals and populations of marine mammals. Conduct research on potential effects of Navy sources on marine mammal behavior, life functions (e.g. feeding, breeding, migrating), vital rates (e.g. adult survival, reproduction), and population level effects. Understanding the effects of naval activities on species or stocks of marine mammals, including effects on annual rates of recruitment and survival. Monitoring and Detection: Continue research and development of technology for detection, classification, and localization of marine mammals. Models & Databases: Continue research to provide tools to support environmental compliance efforts and decision-making related to how marine mammals are affected by anthropogenic sounds. Initiate research using increase in funds to characterize and quantify the cumulative effects of multiple stressors on marine mammal populations. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: UNDERSEA WEAPONRY	13.041	13.852	13.400	0.000	13.400
Description: Undersea Weaponry focuses on the development of enabling technologies to counter threat submarines and surface vessels by increasing Probability of Kill and platform survivability, as well as developing technologies for unmanned undersea vehicles. Research performed within Undersea Weaponry supports several Naval S&T Focus Areas including Power Projection & Integrated Defense, Assure Access to Maritime Battlespace, Autonomy & Unmanned Systems, and Power & Energy. Weapon technology focus areas include: Explosives and Warheads, Guidance and Control (G&C), Simulation Based Design, Propulsion, Power Sources,					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602747N / *Undersea Warfare Applied Res*	**Project (Number/Name)** 0000 / *Undersea Warfare Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Supercavitation, and Counter Weapons/Counter Measures. The ultimate goal of this activity is to provide revolutionary capabilities needed to fill Sea Shield and Sea Strike Warfighter Capability Gaps, to accommodate unique payload limitations through the development of modular and reduced sized undersea weapons based on common technology enablers (where possible), to provide improved platform pre-engagement positioning and fire-control solutions for effective weapon-to-target engagement, and provide countermeasures and counterweapons against current and next-generation undersea weapons. ***FY 2019 Plans:*** Continue applied research related to critical S&T for supercavitation, advanced warheads, propulsion systems for undersea platforms and defense against undersea threats. ***FY 2020 Base Plans:*** Conduct applied research related to critical Science and Technology (S&T) for supercavitation, advanced warheads, new torpedo fuel formulations, small-scale weapon concepts, and propulsion systems for undersea vehicles and platforms. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Accomplishments/Planned Programs Subtotals	54.816	58.049	57.075	0.000	57.075

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

The overall metrics of applied research in undersea warfare are to develop technologies aimed at improving target detection, classification, localization, tracking, increasing attack capabilities against quiet adversary submarines operating in noisy and cluttered shallow water environments, countering enemy torpedoes, providing

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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the ability to conduct long-range engagements, increasing weapons load-out, providing multi-platform connectivity, increasing endurance/survivability, and reducing size and power requirements.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
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COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	4.828	20.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	24.828

A. Mission Description and Budget Item Justification

Efforts for Undersea Warfare Applied Research

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Program Increase	4.828	20.000
FY 2018 Accomplishments: Efforts for Undersea Warfare Applied Research		
FY 2019 Plans: Efforts for Undersea Warfare Applied Research		
Congressional Adds Subtotals	4.828	20.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602750N *I (U)Future Naval Capabilities Applied Research*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	147.219	137.701	154.755	-	154.755	167.590	180.900	184.622	188.333	Continuing	Continuing
0000: *(U)Future Naval Capabilities Applied Research*	0.000	147.219	137.701	154.755	-	154.755	167.590	180.900	184.622	188.333	Continuing	Continuing

A. Mission Description and Budget Item Justification

The efforts described in this Program Element (PE) address the Applied Research associated with the Future Naval Capabilities (FNC) Program. The objective of the work in this PE is to develop and mature technologies needed by the Navy and Marine Corps to initiate FNCs in PE 0603673N Future Naval Capabilities Advanced Technology Development that can be commenced at higher Technology Readiness Levels (TRLs). The FNC Program was restructured for FY 2019 to accelerate transition to the Fleet and Force. This restructuring involved a zero based review of all ongoing FNC projects where each effort was assessed for its technology maturity and transition commitment. Ongoing efforts were categorized as FNCs or Technology Candidates. Some efforts were terminated and others were accelerated to achieve the goals of the restructured program. Funding for FNCs, which have higher Technology Readiness Levels (TRLs of 4/5 to 6) and transition funding commitments, is being resourced in PE 0603673N Future Naval Capabilities Advanced Technology Development. Funding for technology candidates at lower TRLs (3 to 4) is being resourced in this PE. The Office of Naval Research (ONR) is working closely across the Department of the Navy (DON) and Naval Research Enterprise (NRE) to develop high priority technological capabilities needed by the operational forces.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	156.805	147.771	155.625	-	155.625
Current President's Budget	147.219	137.701	154.755	-	154.755
Total Adjustments	-9.586	-10.070	-0.870	-	-0.870
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-10.070			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-2.616	0.000			
• Rate/Misc Adjustments	-0.001	0.000	-0.870	-	-0.870
• Congressional Directed Reductions Adjustments	-6.969	-	-	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602750N *I (U)Future Naval Capabilities Applied Research*

Change Summary Explanation

The increase in FY 2020 is due to increases in Technology Candidate development in Electromagnetic Maneuver Warfare and Combating Terrorism, Ocean Battlespace Sensing, Sea Warfare and Weapons, Warfighter Performance, and Naval Warfare and Weapons as discussed in the individual FY 2020 Plans and increase/decrease statements of each of these R-2 Activity sections.

Technical: Not applicable.

Schedule: Not applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
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COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *(U)Future Naval Capabilities Applied Research*	0.000	147.219	137.701	154.755	-	154.755	167.590	180.900	184.622	188.333	Continuing	Continuing

A. Mission Description and Budget Item Justification

Prior to FY 2019, the underlying Future Naval Capabilities (FNC) Program investments in this program element (PE) were aligned to specific FNC projects. Future budget activity (BA) 2 investments supporting candidate FNC technologies are being developed in order to increase agility, exploit technology advances, and respond quickly to naval needs. This approach facilitates an optimum response when developing and maturing the technology options that will be developed further in PE 0603673N, Future Naval Capabilities Advanced Technology Development.

The FNC Program has been fully restructured for FY 2019 in favor of a more direct and higher level of collaboration, PE R-2 activities are now organized by the Office of Naval Research (ONR) Departments, which are tasked to collaborate with the acquisition stakeholders and their resource sponsors. A complete accounting of the technology candidates being developed and a full disposition of each technology development effort funded in this PE will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: CAPABLE MANPOWER (CMP) ***Description:*** The investments that would have continued in this R-2 Activity have been moved into the activities of the restructed FNC Program. ***FY 2019 Plans:*** N/A ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:*** N/A	8.158	0.000	0.000	0.000	0.000
Title: ENTERPRISE AND PLATFORM ENABLERS (EPE) ***Description:*** The investments that would have continued in this R-2 Activity have been moved into the activities of the restructed FNC Program. ***FY 2019 Plans:***	13.469	0.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
N/A ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:*** N/A					
Title: FNC MANAGEMENT ***Description:*** The investments that would have continued in this R-2 Activity have been moved into the activities of the restructed FNC Program. ***FY 2019 Plans:*** N/A ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:*** N/A	7.915	0.000	0.000	0.000	0.000
Title: FORCE HEALTH PROTECTION (FHP) ***Description:*** The investments that would have continued in this R-2 Activity have been moved into the activities of the restructed FNC Program. ***FY 2019 Plans:*** N/A ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:*** N/A	4.233	0.000	0.000	0.000	0.000
Title: FORCENET (FNT) ***Description:*** The investments that would have continued in this R-2 Activity have been moved into the activities of the restructed FNC Program.	40.645	0.000	0.000	0.000	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
FY 2019 Plans: N/A ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:*** N/A					
Title: POWER AND ENERGY (P&E) ***Description:*** The investments that would have continued in this R-2 Activity have been moved into the activities of the restructed FNC Program. ***FY 2019 Plans:*** N/A ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:*** N/A	10.845	0.000	0.000	0.000	0.000
Title: SEA SHIELD (SHD) ***Description:*** The investments that would have continued in this R-2 Activity have been moved into the activities of the restructed FNC Program. ***FY 2019 Plans:*** N/A ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:*** N/A	34.125	0.000	0.000	0.000	0.000
Title: SEA STRIKE (STK)	27.829	0.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Description: The investments that would have continued in this R-2 Activity have been moved into the activities of the restructed FNC Program. ***FY 2019 Plans:*** N/A ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:*** N/A					
Title: ELECTROMAGNETIC MANEUVER WARFARE (EMW) AND COMBATING TERRORISM ***Description:*** The objective of this activity, new for FY 2019, is to develop and mature technologies in asymmetric and irregular warfare, distributed operations, information dominance, survivability and self-defense to a point where they can be proposed and continued as Future Naval Capabilities (FNC) in program element (PE) 0603673N, Future Naval Capabilities Advanced Technology Development. ***FY 2019 Plans:*** The technologies pursued under this activity include investments that: improve warfighter effectiveness in command, control, computers and communication for small unit naval expeditionary warfighters; enhance fires capabilities so warfighters employed in small, distributed units will have the tools they need to locate and decisively destroy larger enemy forces; improve force protection for small units and individual warfighters against a myriad of enemy attack modes; improve human performance by developing new training technologies, knowledge products, architectures, and systems that can accelerate mental, emotional and cognitive decision-making skill; mature emerging technologies for future intelligence, surveillance and reconnaissance systems; develop and mature new maintenance technologies for expeditionary combat systems; develop new expeditionary energy technologies that support distributed operations from the individual Marine to small units; develop novel technologies and innovative concepts that will improve the maneuverability of the Marine Corps Air Ground Task Force by enhancing the movement of troops and equipment from shipboard to inland objectives; and mature new technologies that will improve the standoff detection and neutralization of improvised explosive devices. ***FY 2020 Base Plans:***	0.000	6.639	11.723	0.000	11.723

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602750N / *(U)Future Naval Capabilities Applied Research*	**Project (Number/Name)** 0000 / *(U)Future Naval Capabilities Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Future Naval Capabilities (FNC) Technology Candidate development in FY 2020 will continue to focus on the technologies noted in the FY 2019 plans. Investments include technologies that: improve warfighter effectiveness in command, control, computers and communication for small unit naval expeditionary warfighters; enhance fires capabilities so warfighters employed in small, distributed units will have the tools they need to locate and decisively destroy larger enemy forces; improve force protection for small units and individual warfighters against a myriad of enemy attack modes; improve human performance by developing new training technologies, knowledge products, architectures, and systems that can accelerate mental, emotional and cognitive decision-making skill; mature emerging technologies for future intelligence, surveillance and reconnaissance systems; develop and mature new maintenance technologies for expeditionary combat systems; develop new expeditionary energy technologies that support distributed operations from the individual Marine to small units; develop novel technologies and innovative concepts that will improve the maneuverability of the Marine Corps Air Ground Task Force by enhancing the movement of troops and equipment from shipboard to inland objectives; and mature new technologies that will improve the standoff detection and neutralization of improvised explosive devices. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase of funds from FY 2019 to FY 2020 is due to naval priorities necessitating an increased investment in technology options for future expeditionary maneuver warfare and combating terrorism Future Naval Capabilities (FNCs). Specific efforts include autonomous and communication technologies that support the last tactical mile for Marine Corps operations as well as artificial intelligence that improve targeting and fire support coordination. A complete accounting of the technologies being developed and a full disposition of each technology development effort will be provided separately to the Congressional oversight committees.					
Title: C4ISR AND SPECIAL PROJECTS ***Description:*** The objective of this activity is to develop and mature technologies in data science, mathematical optimization, computational and information sciences, quantum information sciences, electronics, command and control and combat systems, communications, cyber security, cyber operations, electronic warfare, sensing and surveillance, and precision timing and navigation, as well as technologies for surface and airborne vehicles, and cruise missile defense weapons to a point where they can be proposed and continued as Future Naval Capabilities (FNC) in program element (PE) 0603673N, Future Naval Capabilities Advanced Technology Development.	0.000	67.086	55.720	0.000	55.720

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602750N / *(U)Future Naval Capabilities Applied Research*	**Project (Number/Name)** 0000 / *(U)Future Naval Capabilities Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
FY 2019 Plans: The technologies pursued under this activity include investments that: advance techniques and algorithms for information processing and integration, information operations, information assurance, cyber protection, communications and networking, computational decision-making, accurate decision making, and command and control technologies with a specific focus on enabling rapid; exploit advancements in electronics, sensors and network technologies enabling new and innovative uses of the electromagnetic spectrum in areas of surface and aerospace surveillance, communications, electronic combat, and precision time and navigation; improve adaptive persistent surveillance capabilities; develop new digital radio frequency technologies supporting active aperture, phased arrays capable of performing multiple functions simultaneously; improve soft-kill performance and real-time assessment, as well as provide multiple means to detect and measure incoming threats. ***FY 2020 Base Plans:*** Future Naval Capabilities (FNC) Technology Candidate development in FY 2020 will continue to focus on technologies noted in the FY 2019 plans section above. Investments include technologies that: advance techniques and algorithms for information processing and integration, information operations, information assurance, cyber protection, communications and networking, computational decision-making, accurate decision making, and command and control technologies with a specific focus on enabling rapid; exploit advancements in electronics, sensors and network technologies enabling new and innovative uses of the electromagnetic spectrum in areas of surface and aerospace surveillance, communications, electronic combat, and precision time and navigation; improve adaptive persistent surveillance capabilities; develop new digital radio frequency technologies supporting active aperture, phased arrays capable of performing multiple functions simultaneously; improve soft-kill performance and real-time assessment, as well as provide multiple means to detect and measure incoming threats. FY20 investments focuses on the following areas: communications and networking; decision tools; cyber; sensor deception and defeat; advanced sensing, counter ISR and processing; cross platform technologies; and advanced systems and components. The objectives of communications and networking include maturing promising communications and networking technologies and enable rapid transition to the fleet. The objectives of sensor deception and defeat include maturing the underlying technologies, techniques and algorithms that degrade, neutralize, or destroy an adversary's combat capability. The objectives of decision tools include dedicating applied research to develop decision tools to allow Commanders to rapidly and confidently move from data-to-options-to-informed decisions. The objectives of cyber include maturing innovative cyber approaches to					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602750N / *(U)Future Naval Capabilities Applied Research*	**Project (Number/Name)** 0000 / *(U)Future Naval Capabilities Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
enhance resilience, safety, reliability, and efficiency of cyber systems in warfighting platforms. The objectives of advanced sensing and processing thrust is to maturing sensing system and processing technologies to deliver enhanced operational capabilities for Intelligence, Surveillance, Reconnaissance and Targeting applications. The objectives of cross platform technologies include maturing electro-magnetic enabling technologies that rely on geographic separation of platform sensors to deliver enhanced operational capabilities. The objectives of advanced systems and components include maturing the underlying components and systems for improved electro optical (EO), radio frequency (RF) and Precision, Navigation, and Timing (PNT) systems. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The decrease from FY 2019 to FY 2020 is due to higher naval priorities that led to a realignment of technology candidates across PE (program element) 0602750N, Future Naval Capabilities Applied Research, R-2 Activities.					
Title: OCEAN BATTLESPACE SENSING ***Description:*** The objective of this activity, new for FY 2019, is to develop and mature technologies for antisubmarine warfare, mine warfare and mine countermeasures, and environmental sensing and prediction for the ocean battlespace from sub-seafloor to space to a point where they can be proposed and continued as Future Naval Capabilities (FNC) in program element (PE) 0603673N, Future Naval Capabilities Advanced Technology Development. ***FY 2019 Plans:*** The technologies being pursued under this activity include investments that: improve the detection and neutralization of mines in both the ocean and littoral environment; exploit advancements in maritime sensing, ocean engineering, marine systems, and undersea signal processing, and improve our understanding of the environment and the limits of predictability by maturing technologies in fields ranging from the littoral geosciences to high latitude dynamics. ***FY 2020 Base Plans:*** Future Naval Capabilities (FNC) Technology Candidate development in FY 2020 will continue technologies noted in the FY 2019 plans with a primary focus on improving the ability to exploit environmental sensing,	0.000	20.399	24.476	0.000	24.476

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602750N / *(U)Future Naval Capabilities Applied Research*	**Project (Number/Name)** 0000 / *(U)Future Naval Capabilities Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
modeling and prediction to enable more effective anti-submarine warfare (ASW) and mine warfare (MIW) applications. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase from FY 2019 to FY 2020 was due to naval priorities necessitating an increased investment in technology candidates for future FNCs (Future Naval Capabilities) that leverage advances in Ocean Battlespace Sensing specifically for next generation anti-submarine warfare (ASW) and mine warfare (MIW) sensors, models, and mission planning capabilities. A complete accounting of the technologies being developed and a full disposition of each technology development effort will be provided separately to the Congressional oversight committees.					
Title: SEA WARFARE AND WEAPONS ***Description:*** The objective of this activity, new for FY 2019, is to develop and mature technologies that enable superior warfighting capabilities for surface and sub-surface naval platforms and undersea weaponry to a point where they can be proposed and continued as Future Naval Capabilities in program element (PE) 0603673N, Future Naval Capabilities Advanced Technology Development. ***FY 2019 Plans:*** The technologies being pursued under this activity include investments that: reduce the total life cycle cost of naval platforms and minimize the energy footprint of naval forces by exploiting advancements in hydrodynamics, survivability, electrical and thermal systems, platform structures and autonomy for unmanned surface vehicles; develop new functional and structural materials, materials processing and systems to fulfil the unique requirements of marine and military applications; develop concepts and technologies which enable flexible resilient logistics and maintenance: develop new guidance, control, autonomy, sensors, signal processing, undersea distributed network, energy conversion, propulsion and vehicle technologies that improve the capabilities of sea weapons; improve protection against corrosion and anti-fouling coatings; develop new battery, fuel cell, liquid and solid fuels, and motors for weapons and autonomous vehicles; exploit renewable energy resources and energy efficiency technologies for sea warfare; develop concepts and technologies which enable flexible resilient logistics; develop improved and new acoustic sensors, and related processing and autonomy	0.000	16.738	25.104	0.000	25.104

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602750N / *(U)Future Naval Capabilities Applied Research*	**Project (Number/Name)** 0000 / *(U)Future Naval Capabilities Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
algorithms, to support long-range undersea weapons; and develop primary battery technology for long-range undersea weapons. ***FY 2020 Base Plans:*** The focus in FY 2020 will be on maturing technologies for future FNCs (Future Naval Capabilities) involving off-board refueling and data transfer, autonomous situational awareness, hazard avoidance, and high temperature superconducting magnetic influence sweep payloads for unmanned surface vehicles; advanced batteries to increase torpedo range and endurance; robust power control for integrated surface ship power and combat systems; precision lift in austere at-sea environments for surface ship replenishment and weapons reload; digital tools to automate operation and control of unmanned platforms integrated with manned platforms in mission environments; and in situ repair of shipboard copper-nickel heat exchanger tubing. Additionally, applied research will begin on emerging technologies in the areas of autonomy, digital analytics for platforms and logistics, platform maintenance and sustainability, undersea weapons, advanced manufacturing, and energy systems. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase from FY 2019 to FY 2020 is due to naval priorities in Sea Warfare and Weapons necessitating an increased investment in advance mine-counter-measure technologies for unmanned vehicles and artificial intelligence that improves situational awareness and hazard avoidance for autonomous platforms. A complete accounting of the technologies being developed and a full disposition of each technology development effort will be provided separately to the Congressional oversight committees.					
Title: WARFIGHTER PERFORMANCE ***Description:*** The objective of this activity, new in FY 2019, is to develop and mature technologies that enhance Naval warfighting effectiveness and efficiency within the broad array of Warfighter Performance science and technology domains (Undersea Medicine, Biological Sciences, Biorobotics, Capable Manpower, Command Decision Making, Force Health Protection, Human Robot Interaction, Noise-Induced Hearing Loss, and Training and Simulation) to a point where they can be proposed and continued as Future Naval Capabilities (FNC) in program element (PE) 0603673N, Future Naval Capabilities Advanced Technology Development. ***FY 2019 Plans:***	0.000	8.115	12.710	0.000	12.710

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602750N / *(U)Future Naval Capabilities Applied Research*	**Project (Number/Name)** 0000 / *(U)Future Naval Capabilities Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
The technologies being pursued under this activity include investments that: mature computational, neuroscience, bioscience, bio-mimetic, social/organizational, training, human factors, and decision making technologies to improve warfighter performance and decision making in all environments; exploit advancements in biomaterials, biomedical technologies, expeditionary and undersea medicine, physiology and biophysics, and immunology to increase the survival of casualties through intermediate, life-saving treatments and stabilization techniques and to prevent personnel injuries caused by the stresses of demanding Naval occupations and environments; and develop new manpower, personnel, training, and education technologies that prepare sailors and Marines to fight and win in an information rich, distributed battlespace, get the right warfighters into the right job at the right time with the right tools, and provide a 21st century learning environment designed to deliver the right training. ***FY 2020 Base Plans:*** Technologies developed under this activity enhance Naval operators use of: Autonomy, Artificial Intelligence, and Robotics (AAR), including cross-domain facilitated communication between operators and unmanned vehicles; Communications and Networking/Cyber (CN/C) technologies such as expeditionary command, control, communications, intelligence, surveillance, and reconnaissance (C4ISR); Advanced Analytics and Decision Making (AADM) capabilities including Naval training tools and decision-assist technologies for denied and degraded environments; Manpower, Performance, Protection, and Medical support (MPPM) capabilities such as directed energy bioeffects, monitoring performance in austere environments, and predictors of blast injury. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase from FY 2019 to FY 2020 in Warfighter Performance technologies is due to naval priorities necessitating an increased investment for future FNCs (Future Naval Capabilities) that leverage advances in human-machine integration, communications, predictive and preventive techniques for Naval force health protection; and training technologies for Fleet/Force. A complete accounting of the technologies being developed and a full disposition of each technology development effort will be provided separately to the Congressional oversight committees.					
Title: NAVAL AIR WARFARE AND WEAPONS	0.000	18.724	25.022	0.000	25.022
Description: The objective of this activity, new for FY 2019, is to develop and mature technologies in directed energy, energetic materials, autonomy, electromagnetic launch, and high speed conventional air and surface					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602750N / *(U)Future Naval Capabilities Applied Research*	**Project (Number/Name)** 0000 / *(U)Future Naval Capabilities Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
weapons to a point where they can be proposed and continued as Future Naval Capabilities in PE 0603673N, Future Naval Capabilities Advanced Technology Development. ***FY 2019 Plans:*** The technologies being pursued under this activity include investments that: enhance the offensive and defensive capabilities of tactical missiles and missile systems by developing and maturing new technologies in the areas of high threat time-critical strike, countermeasures to advanced seekers and hostile fire, air vehicle performance, air platform survivability, total ownership cost, operational availability, hypersonic missile defense, naval fires, non-kinetic warfare, unmanned naval aviation, warhead and propulsion energetics and design, navigation, autonomy, airframes, power and energy, propulsion design, sensors, seekers, targeting, directed energy, collaborative operations, advanced manufacturing and maintenance reduction. ***FY 2020 Base Plans:*** The focus of FY2020 will be on maturing technologies for future FNCs that will improve kinetic and non-kinetic capabilities of existing and future naval weapon systems, as well as introduce technological advancements into core Naval operations. Technology investments will be made to introduce artificial intelligence and machine learning into mission planning, make generational enhancements to rocket motor propulsion, investigate sub-system advancement for hypersonic weapons, mature directed energy applications for defense, expand aircraft and ship self-defense capabilities, create alternate aircraft repair methodologies, and improve aircraft-ship interoperability. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase in Naval Air Warfare and Weapons technologies from FY 2019 to FY 2020 is due to naval priorities necessitating an increased investment in technologies for greater insertion and utilization of artificial intelligence and machine learning into Naval operations; investigation into new means for increased availability and sustainability and reduced life cycle cost of capital investments in Naval aircraft; and acceleration of subsystem development for hypersonic weapons and defense.					
Accomplishments/Planned Programs Subtotals	147.219	137.701	154.755	0.000	154.755

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602750N / *(U)Future Naval Capabilities Applied Research*	**Project (Number/Name)** 0000 / *(U)Future Naval Capabilities Applied Research*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

The performance metric for this program element (PE) and the research thrusts it funds can be measured by the number of successful Future Naval Capabilities (FNCs) that are able to be proposed and selected in the FNC budget activity (BA) 3 PE 0603673N, Future Naval Capabilities Advanced Tech Development.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602782N *I Mine & Exp Warfare Applied Res*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	35.430	38.214	36.074	-	36.074	30.298	30.900	31.533	32.167	Continuing	Continuing
0000: *Mine & Exp Warfare Applied Res*	0.000	31.085	36.214	36.074	-	36.074	30.298	30.900	31.533	32.167	Continuing	Continuing
9999: *Congressional Adds*	0.000	4.345	2.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.345

A. Mission Description and Budget Item Justification

This Program Element (PE) provides technologies for Naval Mine Countermeasures (MCM), Expeditionary Warfare, U.S. Naval sea mining, Naval Special Warfare (NSW), and Joint Tri-Service Explosive Ordnance Disposal (EOD) as well as continuing support to research vessels of the U.S. Academic Research Fleet for operations and maintenance that enable applied research at sea. This program is strongly aligned with the Joint Chiefs of Staff Joint Warfighting Capability Objectives through the development of technologies to achieve military objectives with minimal casualties and collateral damage. Within the Naval Transformation Roadmap, this investment will achieve one of three "key transformational capabilities" required by "Sea Shield" as well as technically enable the Ship to Objective Maneuver (STOM) key transformational capability within "Sea Strike" by focusing on technologies that will provide the Naval Force with the capability to dominate the battlespace, project power from the sea, and support forces ashore with particular emphasis on rapid MCM operations. These efforts concentrate on the development and transition of technologies for the MCM-related and Urban Asymmetric/Expeditionary Warfare Operations (UAEO)-related Future Naval Capabilities (FNC) Enabling Capabilities (ECs). The Mine and Obstacle Detection/Neutralization efforts include technologies for clandestine and overt minefield reconnaissance, organic ship self-protection, organic minehunting and neutralization/breaching. The Urban Asymmetric Operation effort includes critical warfighting functions such as Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR), fires, maneuver, sustainment, etc. The Naval Special Warfare and Explosive Ordnance Disposal technology efforts concentrate on the development of technologies for safe near-shore mine detection, diver mobility and survivability, and ordnance disposal operations.

The activities described in this program element PE address future Navy and Marine Corps capabilities needed to maintain maritime superiority and ensure national security. They are based on input from Naval Research Enterprise stakeholders (including the Naval enterprises, the combatant commands, OPNAV and Headquarters Marine Corps) and are designed to exploit breakthroughs in science and technology in order to deliver maximum warfighting benefit to our sailors and marines. These efforts are aligned with shared priorities throughout the whole of RDT&E in order to quickly advance new capabilities from discovery to deployment across the warfighting domains.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602782N *I Mine & Exp Warfare Applied Res*

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	32.733	37.545	36.273	-	36.273
Current President's Budget	35.430	38.214	36.074	-	36.074
Total Adjustments	2.697	0.669	-0.199	-	-0.199
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-1.331			
• Congressional Rescissions	-	-			
• Congressional Adds	-	2.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-1.000	0.000			
• SBIR/STTR Transfer	-0.802	0.000			
• Program Adjustments	0.000	0.000	-0.199	-	-0.199
• Rate/Misc Adjustments	-0.001	0.000	0.000	-	0.000
• Congressional Add Adjustments	4.500	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Program Increase*	1.931	0.000
Congressional Add: *Submersible Research*	2.414	0.000
Congressional Add: *Unmanned Aerial and Deep Submersible Platforms*	0.000	2.000
Congressional Add Subtotals for Project: 9999	4.345	2.000
Congressional Add Totals for all Projects	4.345	2.000

Change Summary Explanation

Technical: Not applicable.

Schedule: Not applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602782N / *Mine & Exp Warfare Applied Res*	Project (Number/Name) 0000 / *Mine & Exp Warfare Applied Res*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *Mine & Exp Warfare Applied Res*	0.000	31.085	36.214	36.074	-	36.074	30.298	30.900	31.533	32.167	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project focuses on reducing the time involved in conducting MCM operations and increasing safe standoff from minefields. It develops and transitions technologies for MCM-related and UAEO-related Future Naval Capability Enabling Capabilities (FNC ECs). The MCM effort includes technologies for clandestine and overt minefield reconnaissance, organic ship self-protection, organic minehunting, neutralization/breaching and clearance. The Littoral Warfare effort includes critical warfighting functions such as C4ISR, fires, maneuver, sustainment, etc. The sea mining effort emphasizes technologies for future sea mines. The Naval Special Warfare and Explosive Ordnance technology efforts concentrate on the development of technologies to enhance diver capabilities including: safe near-shore mine sensing, mobility and survivability, and ordnance disposal operations.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: MINE TECHNOLOGY	3.659	6.962	7.635	0.000	7.635
Description: Mine Technology: This activity primary focuses on developing and demonstrating technologies to support on-demand battlespace shaping through advanced undersea weapons and next generation mining concepts. Efforts include Command & Control to support remote control, advanced sensing technologies, compatibility with unmanned delivery options, detection & classification, and targeting solutions. The program, Modular Undersea Effectors (MUSE), is a critical Science and Technology effort both to support Fleet demand for capability and prototype development for next generation mining concepts, and to develop and investigate flexible, scalable, and asymmetric technologies to deliver next generation mining effects for legacy programs of record. This program provides critical S&T for development and capability in new acquisition programs of record.					
FY 2019 Plans: Conduct applied research in remote control, advanced minefield concepts, minefield planning, and advanced sensors / signal processing. Efforts involved in this area include developments in advanced sensors and algorithmic capabilities that are applicable toward existing target detection devices (TDDs), analysis of intermediate and deep water minefield concepts, development of concepts for semi-autonomous and remote controlled mines and minefields, and assessment of sea mine technologies in order to maintain a level of					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602782N / *Mine & Exp Warfare Applied Res*	**Project (Number/Name)** 0000 / *Mine & Exp Warfare Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
expertise in naval mines. Initiate applied research in modeling and applying novel mine sensing modalities and modeling and development of advanced minefield effects. ***FY 2020 Base Plans:*** Conduct advanced technology development in advanced mining technologies for clandestine, flexible, and scalable minefield deployment, longevity, and endurance, to include remote control, advanced sensing for detection and classification, command & control (C2), and more discriminative targeting solutions. Efforts in this thrust include prototyping and demonstration of advanced sensors and sensor configuration technologies for improved discrimination as well as communications, command, and control technologies. Continue prototyping and demonstration for next-generation target detection devices and mine effects. Joint Service Explosive Ordnance Disposal (EOD): Conduct applied technology development and demonstration in electro-optic & acoustic technologies for buried mine detection, robotic manipulation for ordnance exploitation & neutralization, standoff detection and classification for ordnance, and identification of explosives. Efforts in this thrust include prototype and demonstration of laser interferometric sensor/systems for detection of buried objects, highly dexterous dual manipulator systems (manipulators, controllers) for EOD robots for precision render safe and neutralization missions, technologies for low-observable underwater ordnance neutralization and technologies for the inspection of underwater explosive threats. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: MINE/OBSTACLE DETECTION ***Description:*** This activity focuses on applied research to enable longer detection ranges and precise mine location with fewer false alarms in a variety of challenging environments. It supports Discovery and Invention (D&I) and Mine Countermeasures (MCM)-related Future Naval Capabilities (FNCs). Efforts in Synthetic Aperture Sonar (SAS) technologies for longer range detection and classification of mine-like targets and magnetic gradiometer sensing and electro-optic (EO) technology for buried mine identification, and sensor integration onto Autonomous Underwater Vehicles (AUVs) are being addressed. EO sensor research develops algorithms to enable image processing for rapid overt reconnaissance from an Unmanned Aerial Vehicle (UAV). Other processing, classification and data fusion techniques to reduce operator workload, and a mine burial prediction	17.003	17.969	17.329	0.000	17.329

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602782N / *Mine & Exp Warfare Applied Res*	**Project (Number/Name)** 0000 / *Mine & Exp Warfare Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
"expert system" are also being developed. Efforts also support development of MCM Mission Modules for Littoral Combat Ships. The program is strongly aligned with the Oceanographer of the Navy (N2/N6E) and the research topics addressed by this sub activity reflects the priorities for improved forecasts of the operational environment and the development and use of autonomous systems for the collection of environmental observations and continuing support to research vessels of the U.S. Academic Research Fleet for operations and maintenance that enable science at sea. This Program requires field research that involves participation in Navy environmental planning efforts including environmental planning documents (Environmental Impact Statements). The use of active acoustic transmissions requires modeling of the acoustic effects of sound on marine life. ***FY 2019 Plans:*** Conduct applied research in novel minehunting technology areas that will ultimately enable unmanned systems to operate flexibly across a wide range of dynamic and unstructured environments and operations. Research thrusts include development of new algorithms, coding schemes, prototype hardware, and problem domain understanding for acoustic communications between unmanned MCM systems in the dynamic environments unique to minehunting; new transduction designs and sensor concepts appropriate for miniaturizing MCM capabilities onto substantially smaller unmanned systems and operating with increased autonomy; algorithmic approaches and new hardware designs that consolidate and optimize sensing, navigation, and communications for smaller autonomous mobile mine hunting and neutralization systems. Conclude development of a high source level projector that can extend the maximum detection range of the Low Frequency Broadband (LFBB) Mine Identification System. Conclude Phase 2 of Advanced Mission Module Technology Development. Conclude development of system concepts for wide area detection of surface and submerged drifting mines. Initiate joint sensing and communication approaches for multi-vehicle mine hunting. Initiate performance estimation for automatic target recognition on non-imaging systems. Continuing support to research vessels of the U.S. Academic Research Fleet for operations and maintenance that enable science at sea. Undersea Warfare: Perform laboratory, field, and theoretical/numerical studies that creates new solutions to enable naval forces to conduct more rapid and effective mine detection and classification such as: the development of unmanned underwater vehicle (UUV) autonomy to interactively sense and exploit the ambient environmental conditions to optimize performance; and to characterize the flow generated by biomimetic					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602782N / *Mine & Exp Warfare Applied Res*	**Project (Number/Name)** 0000 / *Mine & Exp Warfare Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
propulsion approaches leading to development of tools to inform the design of future UUVs utilizing such propulsion mechanisms.					
FY 2020 Base Plans: Conduct applied research in novel mine hunting technologies to enable unmanned systems to operate flexibly across a wide range of dynamic and unstructured environments and operations. Research thrusts include the development of new algorithms, innovative processing schemes, prototype hardware, studies of acoustic communications between unmanned MCM systems in dynamic environments; new transducer designs and sensors for miniaturizing MCM capabilities onto smaller unmanned systems and operating with increased autonomy; novel algorithmic approaches and hardware designs that consolidate and optimize sensing, navigation, and communications for smaller autonomous mine hunting and neutralization systems. Conduct investigations of joint sensing and communication approaches for multi-vehicle mine hunting; and, performance estimation for automatic target recognition on non-imaging systems. Laboratory, field, and theoretical/numerical studies will provide new solutions to enable more rapid and effective mine detection and classification. Emphasis will be placed on reducing timelines, or even eliminating, post-mission analysis through enhanced scene understanding derived from acoustic and/or other sensing modalities. Specific research activities include; the development of Unmanned Underwater Vehicle (UUV's) autonomy to exploit the ambient environmental conditions to optimize performance; extend the reach of MCM UUVs to operate at deeper depths; characterization of the flow generated by various propulsion approaches; measurements and modeling of the physics associated with the acoustic interactions with targets and the environment, which can be exploited for detection and classification; investigations that lead to new parameterizations of the ocean seabed applicable to modern mine hunting systems; investigations that link observable impacts on acoustic scattering and/or propagation with the underlying phenomenology that affects the environment, including oceanographic and biologic processes; investigations aimed at linking target scattering physics modalities to specific properties in the feature space domain used for Automatic Target Recognition.					
FY 2020 OCO Plans: N/A					
FY 2019 to FY 2020 Increase/Decrease Statement:					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602782N / *Mine & Exp Warfare Applied Res*	**Project (Number/Name)** 0000 / *Mine & Exp Warfare Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
There is no significant change from FY 2019 to FY 2020.					
Title: MINE/OBSTACLE NEUTRALIZATION	0.415	0.445	0.435	0.000	0.435
Description: Activity includes applied research to support selected Mine Counter-Measures related Future Naval Capabilities (FNC) for rapid mine and obstacle neutralization and sea mine jamming techniques to increase surface ship safe standoff from threat mines. It includes various lethality, vulnerability and dispensing computational tools, models and assessments to support the various far-term Surf Zone and Beach Zone mine and obstacle breaching concepts. ***FY 2019 Plans:*** Conduct applied research in rapid mine and obstacle neutralization and mine sweeping techniques to increase surface ship safe standoff from threat mines. Efforts involved in this area include various lethality, vulnerability, and dispensing models, assessments, and algorithmic approaches to support surf zone and beach zone mine and obstacle breaching concepts; techniques for neutralization of buried mines; techniques for emulation sweep; and investigating the coupling of reacquire & identify capabilities with precision neutralization for buried mines. Conclude development of system concepts for autonomous neutralization of surface and submerged drifting mines. ***FY 2020 Base Plans:*** Conduct applied research to support rapid mine and obstacle neutralization and mine sweeping techniques to enable maneuver of joint forces and increase the safe standoff of various tactical platforms and surface ships from the threat of mines. Research thrusts include development of lethality, vulnerability models, technology concept assessments, and algorithmic approaches to support neutralization of mines and obstacles in all water depths and on the beach, which includes Surf Zone and Beach Zone mine and obstacle breaching concepts; novel approaches for neutralization of buried mines; advanced techniques for emulation sweep; and methods to enable precision neutralization of buried mines. Conclude assessment of preliminary methods for emulation sweep. Conclude investigation of coupling of reacquire and identify capabilities with precision neutralization of buried mines. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:***					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602782N / *Mine & Exp Warfare Applied Res*	**Project (Number/Name)** 0000 / *Mine & Exp Warfare Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
There is no significant change from FY 2019 to FY 2020.					
Title: SPECIAL WARFARE/EOD	10.008	10.838	10.675	0.000	10.675
Description: The goal of this effort is to develop technologies to extend stand-off of special operations and Explosive Ordnance Disposal (EOD) forces in clandestine hydrography, mine clearance and port security missions while increasing the range and effectiveness of divers. Advanced technologies are needed to gain access to areas contaminated by area-denial sensors and/or booby traps. Developed technologies will transition to the Joint Service EOD Program, the Naval EOD Program, or the DOD Technical Response Group. This activity includes applied research in sensor technology for Naval Special warfare (NSW) and EOD autonomous and handheld sonar systems to increase detection range and accuracy in harsh environments. Other efforts include mission support technology improvements for AUVs and human divers - such as communications, navigation and life support. ***FY 2019 Plans:*** Conduct applied research in sensor technology for NSW and EOD autonomous and handheld sonar systems, mission support technology improvements for AUVs and human divers (e.g., communications, navigation, and life support), and threat identification, exploitation, and remediation technologies. Efforts involved in this area include development of technologies to excavate buried IEDs, dual manipulator robots for complex underwater EOD missions, technologies to enhance diver situational awareness and autonomous inspection of ship hulls, support of Joint Service Explosive Ordnance Disposal (JSEOD) applied research, and detection of trace and bulk explosive materials. Conclude investigation of multi-modal signature reduction technologies for wet/dry-submersibles and semisubmersibles. Initiate modeling and development of concepts to increase mobility efficiency for combat divers. ***FY 2020 Base Plans:*** Conduct applied research in sensor, render-safe and neutralization technologies for NSW and EOD autonomous and handheld systems, mission support technology enhancements for manned and unmanned platforms (air, surface or undersea) and new concepts to increase the efficiency and mobility of unmanned platforms and divers (e.g., communications, propulsion, navigation, and life support), and threat identification, exploitation, and remediation technologies. Efforts include development of technologies which will: excavate buried Improvised Explosive Device; use advanced robotic manipulators for complex underwater EOD missions; support Joint Service Explosive Ordnance Disposal (JSEOD) applied research; detect trace and bulk explosive materials at extended standoff distances; detect buried improvised explosive devices, explosive threats and mines using handheld or unmanned platforms; inspect explosive threats from safe standoff, enhance diver situational					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602782N / *Mine & Exp Warfare Applied Res*	**Project (Number/Name)** 0000 / *Mine & Exp Warfare Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
awareness and autonomous inspection of structures; conduct vessel interdiction; allow tagging, tracking and locating of targets; conduct characterization, inspection, surveillance and reconnaissance of denied and under canopy areas. Conclude assessment of excavation techniques. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Accomplishments/Planned Programs Subtotals	31.085	36.214	36.074	0.000	36.074

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

The overall metrics of this applied research program are the development of technologies which focus on the Expeditionary Warfare challenge of speeding the tactical timeline and increasing safe standoff from minefields. Individual project metrics include the transition of 6.2 technology solutions into 6.3 advanced technology programs.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602782N / *Mine & Exp Warfare Applied Res*				Project (Number/Name) 9999 / *Congressional Adds*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
9999: *Congressional Adds*	0.000	4.345	2.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.345

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Program Increase ***FY 2018 Accomplishments:*** Funds will be used to accelerate development of capabilities to reduce timelines in MCM operations and to study cross-domain hybrid unmanned systems. ***FY 2019 Plans:*** N/A	1.931	0.000
Congressional Add: Submersible Research ***FY 2018 Accomplishments:*** Funds will be used to accelerate development of autonomous vehicle behaviors in cluttered environments. ***FY 2019 Plans:*** N/A	2.414	0.000
Congressional Add: Unmanned Aerial and Deep Submersible Platforms ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Funds will be used to further development of autonomous aerial and submersible platforms in cluttered environments.	0.000	2.000
Congressional Adds Subtotals	4.345	2.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602782N / *Mine & Exp Warfare Applied Res*	**Project (Number/Name)** 9999 / *Congressional Adds*

E. Performance Metrics

Congressional Interest Items not included in other Projects.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602792N *I (U)Innovative Naval Prototypes(INP) Applied Res*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	160.884	154.085	153.062	-	153.062	160.537	163.711	166.933	170.290	Continuing	Continuing
0000: *(U)Innovative Naval Prototypes(INP) Applied Res*	0.000	160.884	154.085	114.427	-	114.427	132.026	137.650	166.933	170.290	Continuing	Continuing
2481: *EMRG*	0.000	0.000	0.000	7.632	-	7.632	0.000	0.000	0.000	0.000	0.000	7.632
2958: *Cyberspace Activities*	0.000	0.000	0.000	31.003	-	31.003	28.511	26.061	0.000	0.000	0.000	85.575

Note

In FY 2020, the Applied Research Electro-Magnetic Railgun (EMRG) high-power, kinetic energy weapon prototype development effort was realigned from Project Unit 0000 to Project Unit 2481 within this PE.

In FY 2020 a stand alone Artificial Intelligence (AI) R-2 Activity was established in Project Unit 0000 to consolidate and coordinate the acceleration of AI investments.

The FY 2017 Appropriation Act encouraged the services to realign Cyberspace Activity (CA) resources into individual cost codes, projects or program elements (PEs) in order to provide additional clarity and enhanced oversight of cyberspace resources. Within this PE, cyber funding was moved from Proj 0000 Innovative Naval Protoypes (INP) Applied Research to Proj 2958 Cyberspace Activities beginning in FY20, which was established to isolate and identify cyberspace activities.

A. Mission Description and Budget Item Justification

The efforts described in this Program Element (PE) address the Applied Research associated with the Innovative Naval Prototypes (INP) Program. These investments represent game-changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature as they would dramatically change the way naval forces fight. INPs push the imagination of our nation's technical talent to deliver transformational warfighting capabilities. The projects in this portfolio are high risk, technically challenging development efforts that offer the potential of high warfighting payoff in the future. The goal of these investments is to develop and demonstrate the viability of new technological capabilities via experimental prototypes that prove the new capability could be implemented if an acquisition program were to be established to support further development. These investments are selected by a process that involves senior leadership in the Department of the Navy.

Developing INPs requires a systematic expansion and application of knowledge to develop useful materials, devices, and systems oriented toward the design and development of prototypes applicable to specific mission area requirements. The efforts funded within this PE translate promising basic research into solutions for broadly defined military needs. These efforts include developing breadboard hardware and algorithms that establish the initial feasibility and practicality of proposed solutions to technological challenges, such as concept exploration efforts, studies, investigations, and non-system specific technology efforts.

Due to the nature of these projects, technology development plans have been written with limited details due to information security concerns. Specific information on each project will be provided separately to the Congressional oversight committees.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602792N *I (U)Innovative Naval Prototypes(INP) Applied Res*

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	171.146	159.697	161.381	-	161.381
Current President's Budget	160.884	154.085	153.062	-	153.062
Total Adjustments	-10.262	-5.612	-8.319	-	-8.319
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-5.612			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-3.262	0.000			
• Program Adjustments	0.000	0.000	-0.776	-	-0.776
• Rate/Misc Adjustments	0.000	0.000	-7.543	-	-7.543
• Congressional Directed Reductions Adjustments	-7.000	-	-	-	-

Change Summary Explanation

Technical: Not applicable.

Schedule: Not applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602792N / *(U)Innovative Naval Prototypes(INP) Applied Res*	Project (Number/Name) 0000 / *(U)Innovative Naval Prototypes(INP) Applied Res*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *(U)Innovative Naval Prototypes(INP) Applied Res*	0.000	160.884	154.085	114.427	-	114.427	132.026	137.650	166.933	170.290	Continuing	Continuing

Note

Beginning in FY 2020, the Applied Research Electro-Magnetic Railgun (EMRG) high-power, kinetic energy weapon prototype development effort was realigned from Project Unit 0000 to Project Unit 2481 within PE 0602792N.

A. Mission Description and Budget Item Justification

Innovative Naval Prototypes (INP) investments are typically 4-8 years in duration. They provide a continuance of basic research by maturing technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. It is intended that prototypes developed within this program, requiring both Budget Activity 2 (BA2) and Budget Activity 3 (BA3) funding, are demonstrated in a relevant environment to prove the feasibility of the new technological capability. The portfolio is periodically refreshed through the selection of new INPs as existing ones are completed. Successful experiments and demonstrations are intended to present the Department of the Navy with a programmatic challenge as these new capabilities can lead to the obsolescence of existing capabilities, requiring significant decisions as to the path forward for integrating the new technological capabilities into the warfighting systems of the future. INPs have been collectively grouped into R-2 Activities that include Unmanned and Autonomous Systems, Directed Energy/Electric Weapons, Electromagnetic Maneuver Warfare, Cyber, Undersea Warfare and Artificial Intelligence.

Due to the nature of these projects, technology development plans have been written with limited details due to information security concerns. Specific information on each project will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: Cyber	17.567	23.535	0.000	0.000	0.000
FY 2019 Plans: Continue Applied Research effort to develop leap-ahead resilient cybersecurity tools that will enable our warfighting platforms to fight through current and future cyber intrusions.					
FY 2020 Base Plans: N/A					
FY 2020 OCO Plans: N/A					
FY 2019 to FY 2020 Increase/Decrease Statement:					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602792N / *(U)Innovative Naval Prototypes(INP) Applied Res*	**Project (Number/Name)** 0000 / *(U)Innovative Naval Prototypes(INP) Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
The FY 2019 to FY 2020 decrease reflects the realignment of funding within this PE from Proj 0000 Innovative Naval Protoypes (INP) Applied Res to Proj 2958 Cyberspace Activities.					
Title: Directed Energy / Electric Weapons	56.333	45.788	29.531	0.000	29.531
Description: This R-2 Activity contains all Applied Research Innovative Naval Prototype (INP) investments that are developing new technologies for directed energy, electric weapons, and hypersonic cruise and air launch booster technology. Future adversaries will seek to neutralize U.S. conventional advantages by capitalizing on asymmetric capabilities that incorporate mobility, range, speed and deception. Naval platforms will be on the front line of our national integrated defensive capabilities to defeat these emerging threats that are proliferating. At the same time, the fleet/force must be able to effectively strike targets with survivable, scalable and cost-effective weapons that have sufficient range, speed and accuracy to complete a variety of missions while reducing risk to our warfighters and without creating unnecessary collateral damage or loss of life. Technologies within this activity will provide scalable lethality through enabling multi-domain, integrated, scalable kinetic and non-kinetic systems for offensive of defensive purposes.					
FY 2019 Plans: Continue Applied Research development addressing the unique technical challenges inherent in the construction, assembly and operation of a high-power, kinetic energy weapon prototype capable of repeatedly launching long range, precision guided projectiles using electricity instead of chemical propellants. Conduct a full-scale, rep-rate composite barrel structural demonstration for this project. Continue Applied Research efforts to develop a radio frequency effects payload (a joint USAF/USN project) with scalable electromagnetic effects. Conduct payload shock/vibration testing at the subsystem level. Initiate development of a government laboratory laser testing environment that is representative of a shipboard environment. Conduct the applied research associated with a land-based test at White Sands Missile Range that will involve ship integration and sea testing on an LPD ship.					
FY 2020 Base Plans: Conduct development efforts for a radio frequency effects payload (a joint USAF/USN project) with scalable electromagnetic effects. Conduct the Applied Research supporting initial lab and integration testing.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602792N / *(U)Innovative Naval Prototypes(INP) Applied Res*	**Project (Number/Name)** 0000 / *(U)Innovative Naval Prototypes(INP) Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Conduct research to develop a hypersonic cruise missile that is affordable and effective to mature critical technologies. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The decrease from FY 2019 to FY 2020 is due to a planned ramp down in Directed Energy/Electric Weapons Applied Research as some of the difficult technology challenges are being achieved, and the realignment of Applied Research Electro-Magnetic Railgun (EMRG) high-power, kinetic energy weapon prototype development effort to a newly created Project Unit 2481 in PE 0602792N. Specific information on each project will be provided separately to the Congressional oversight committees.					
Title: Electromagnetic Maneuver Warfare	23.607	11.072	7.056	0.000	7.056
Description: This R-2 Activity contains all Applied Research Innovative Naval Prototype (INP) investments that are developing new technologies for Electromagnetic Maneuver Warfare (EMW). The electromagnetic spectrum is a key operational maneuver space enabled by continuous, real-time awareness of all spectrum activity. This R-2 Activity supports spectrum dominance, which included efforts that focus on communications, surveillance, EMW and electronics to understand and shape the battle space. The ability to assure access to the full spectrum is essential for battle space awareness and threat surveillance/weapon sensor engagement. Technologies within this activity will provide for integrated and distributed forces capable of dynamic synchronized actions through interoperable forces by incorporation of autonomous/ disaggregated systems to increase flexibility and reach within the electromagnetic spectrum. ***FY 2019 Plans:*** Continue Applied Research efforts to develop technology which will enable a strike group to work cooperatively in the Electromagnetic Spectrum (EMS) to optimize EW, Information Operations (IO), communications, and radar performance. Conduct the Applied Research supporting an at-sea Flexible Distributed Array Radar demonstration. ***FY 2020 Base Plans:*** Develop efforts to enable a strike group to work cooperatively in the electromagnetic spectrum by optimizing electronic warfare, information operations, communications and radar performance. Conduct the Applied					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602792N / *(U)Innovative Naval Prototypes(INP) Applied Res*	**Project (Number/Name)** 0000 / *(U)Innovative Naval Prototypes(INP) Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Research associated with the final design for a Low-band Radio Frequency Intelligent Distribution Resource (LowRIDR) for the EMC2 prototype. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The decrease from FY 2019 to FY 2020 is due to a planned ramp down in applied research as work in this technology area is approaching completion. Specific information on each project will be provided separately to the Congressional oversight committees.					
Title: INP Management ***Description:*** This R-2 Activity was discontinued in FY 2019. ***FY 2019 Plans:*** N/A ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:*** N/A	1.470	0.000	0.000	0.000	0.000
Title: Undersea Warfare ***Description:*** This R-2 Activity contains all Applied Research Innovative Naval Prototype (INP) investments that are developing new technologies for Undersea Warfare. This R-2 Activity explores development of technologies to achieve and maintain undersea dominance in the areas of Anti-Submarine Warfare (ASW) and mine warfare, and to improve environmental sensing capabilities which support the Undersea Warfare domain. Technologies within this activity will dramatically improve sensing and sense-making, provide integrated and distributed autonomy to forces, and provide scalable lethality through development of kinetic and non-kinetic effects payloads. ***FY 2019 Plans:*** Affordable Mobile ASW Surveillance System (AMASS)	14.439	13.602	14.046	0.000	14.046

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602792N / *(U)Innovative Naval Prototypes(INP) Applied Res*	**Project (Number/Name)** 0000 / *(U)Innovative Naval Prototypes(INP) Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Continue AMASS, a three year project that will verify our understanding of the physical phenomenon postulated to give superior performance. Complete Design source and receiver configurations suitable for future spiral development as an autonomous deployable system. The first of three units will be fabricated and assembled, and fabrication and assembly of the second and third unit will begin. Develop software for real time control of the source and post-test control of the receiver. Develop software to analyze data that will be collected. Initiate Applied Research efforts to develop the technology required to operate an unmanned environmental observing system in strategically important locations in support of persistent monitoring of environmental conditions. ***FY 2020 Base Plans:*** Conduct applied research associated with the development of an Arctic Mobile Observing System (AMOS), a prototype mobile sensing system incorporating Arctic-capable unmanned underwater vehicles that can be deployed anywhere in the Arctic using a central, ice-based buoy node to provide the critical infrastructure (power, communication, navigation, and environmental intelligence). AMOS will provide the Navy with a persistent Arctic presence and environmental Arctic domain awareness at a lower cost and less risk than manned platforms. The combination of Unmanned Underwater Vehicle (UUV) assets included in an AMOS node will determine the range, sensing capability and persistence of each node, and can be chosen based on need and Arctic location. Work under this effort will involve understanding the trade-offs and capabilities for the prototype system. Affordable Mobile ASW Surveillance System (AMASS) Complete Applied Research efforts to verify performance of components to enable next generation Anti-Submarine Warfare (ASW) capability. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** No significant change from FY 2019 to FY 2020					
Title: Unmanned and Autonomous Systems	47.468	60.088	48.925	0.000	48.925

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602792N / *(U)Innovative Naval Prototypes(INP) Applied Res*	**Project (Number/Name)** 0000 / *(U)Innovative Naval Prototypes(INP) Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Description: This R-2 Activity contains all Applied Research Innovative Naval Prototype (INP) investments that are developing new technologies for Unmanned and Autonomous Systems. Increased proliferation of inexpensive lethal threats targeting individual warfighters and high-value assets, combined with continued rapid advances in computing, power and energy, robotics, sensors and position guidance technologies, drives the requirement to augment expensive manned systems with less expensive, unmanned, fully autonomous systems that can operate in all domains. Technologies within this activity will provide integrated and distributed, autonomous and disaggregated systems to increase flexibility and reach. ***FY 2019 Plans:*** Continue applied research of autonomous payloads for large and extra-large unmanned undersea vehicles. Continue applied research of autonomy algorithms, the command and control architecture needed for swarm control (a flying ad-hoc network), effects payloads and sensing modalities. Continue applied research of autonomous control for medium displacement unmanned surface systems, focusing on research into common behaviors across multiple missions, advancements in route planning, and additional perception modalities. Complete applied research to include an at-sea demonstration of a fuel cell system on an available Unmanned Undersea Vehicle (UUV) of suitable size. Conduct applied research into small multi-Unmanned Surface Vehicle (USV) autonomous control, including research into common multi-USV behaviors across multiple missions, multi-USV task recognition/allocation/ execution and advanced perception. ***FY 2020 Base Plans:*** Conduct development of autonomous payloads for extra-large unmanned undersea vehicles. Conduct development of technologies that continue to support development of a scalable system of inexpensive Unmanned Aerial Vehicles (UAVs) in order to provide a disruptive capability in contested urban environments against anti-access area denial defenses.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602792N / *(U)Innovative Naval Prototypes(INP) Applied Res*	**Project (Number/Name)** 0000 / *(U)Innovative Naval Prototypes(INP) Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Conduct development of technologies that will enable a self-deploying, highly autonomous, multi-mission/multi-payload Unmanned Surface Vehicle (USV) capable of operating with carrier strike groups and surface action groups at a very low operating cost. Conduct development of an autonomous control system for multiple Unmanned Surface Vehicle (USVs) consisting of cooperative task allocation, cooperative route planning/behaviors, and shared situational awareness. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2019 to FY 2020 decrease is due to the completion of applied research associated with a fuel cell system for unmanned undersea vehicles. Funding realigned specific information on each project will be provided separately to the Congressional oversight committees.					
Title: Artificial Intelligence ***Description:*** This R-2 Activity contains coordinated AI investments for Applied Research Innovative Naval Prototype (INP) efforts that develop new technologies applying Artificial Intelligence. This Applied Research, being conducted in coordination with complimentary Advanced Technology Development investment in Program Element (PE) 0603801N INP, will create Artificial Intelligence applications for predictive mission-focused analytics that autonomously gather, analyze, compile, interpret, and visualize a fused tactical & national all source data picture to improve decision making speeds and enable a distributed Artificial Intelligence capability that can function in a harsh and adversarial environment and is able to determine an optimal response and accelerate reactions to real time. ***FY 2019 Plans:*** N/A ***FY 2020 Base Plans:*** Align Applied Research associated with the development of a prototype multi-domain integrated fires control capability enabled by Artificial Intelligence (AI) allowing for real-time, force-wide electromagnetic maneuver and soft-kill and hard-kill battle management. Thrust areas being explored include distributed combat data systems, AI battle management tools, and embedded machine learning.	0.000	0.000	14.869	0.000	14.869

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602792N / *(U)Innovative Naval Prototypes(INP) Applied Res*	**Project (Number/Name)** 0000 / *(U)Innovative Naval Prototypes(INP) Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Align Applied Research supporting the goal of demonstrating machine speed battle management tools to support continuous analysis and planning at the operational and tactical levels and dynamically synchronizing forces across intelligence, surveillance and reconnaissance, Command and Control and combat systems. Thrust areas being explored include distributed combat data systems, adaptive data analytics and a course of action and intentions assessment AI application. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase from FY 2019 to FY 2020 is due to the acceleration of aligned Artificial Intelligence R-2 Activity being initiated. This project is being initiated in response to the National Defense Strategy guidance for modernization of advanced autonomous systems. It will enable a broad array of autonomous functions, such as machine-speed decision making in Electromagnetic Warfare (EW) and Spectrum Management operations, through improvements in artificial intelligence. Specific information on each project will be provided separately to the Congressional oversight committees.					
Accomplishments/Planned Programs Subtotals	160.884	154.085	114.427	0.000	114.427

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

In all cases, the technologies being developed within this Program Element (Applied Research associated with the Innovative Naval Prototypes (INP) Program) support the Department of the Navy INP Program and are managed at the Office of Naval Research. The primary technological metrics used in this PE involve experiments and tests that demonstrate proof of concept for the technological capability being developed. Technology development is informed by periodic interaction with Naval warfighters, resource sponsors and the acquisition community. At the lowest level, each project is evaluated against technical and financial milestones on a frequent basis. Annually, each project is reviewed in depth for technical performance and development status by the Chief of Naval Research. Department of the Navy leadership is briefed on the portfolio's status by the Chief of Naval Research.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602792N / *(U)Innovative Naval Prototypes(INP) Applied Res*	Project (Number/Name) 2481 / *EMRG*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
2481: *EMRG*	0.000	0.000	0.000	7.632	-	7.632	0.000	0.000	0.000	0.000	0.000	7.632

Note

Beginning in FY 2020, the Applied Research Electro-Magnetic Railgun (EMRG) high-power, kinetic energy weapon prototype development effort was realigned from Project Unit 0000 to Project Unit 2481 within PE 0602792N.

A. Mission Description and Budget Item Justification

Electro-Magnetic Railgun (EMRG) is a high-power, kinetic energy weapon capable of launching precision guided projectiles using electricity instead of chemical propellants. When released into the railgun, an electric pulse launches the projectile at speeds up to Mach 6. EMRG will bring new capabilities, increased capacity and improved operational economy to fleet operations at sea. With its increased velocity and extended range, the EM Railgun provides multi-mission potential for hypersonic missile defense, anti-air & surface warfare, and naval surface fire support.

EMRG is a multi-year effort in various stages of research and development within with the Navy's Innovative Naval Prototypes (INP) family of RDT&E programs. INP investments are typically 4-8 years in duration. They provide a continuance of basic research by maturing technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. It is intended that prototypes developed within this program, requiring both Budget Activity 2 (BA2) and Budget Activity 3 (BA3) funding, are demonstrated in a relevant environment to prove the feasibility of the new technological capability. Successful experiments and demonstrations are intended to present the Department of the Navy with a programmatic challenge as these new capabilities can lead to the obsolescence of existing capabilities, requiring significant decisions as to the path forward for integrating the new technological capabilities into the warfighting systems of the future. The Activity identified in Project Unit 2481 specifically addresses Applied Research in support of the Electro-Magnetic Railgun (EMRG) high-power, kinetic energy weapon prototype development INP effort.

Due to the nature of these projects, technology development plans have been written with limited details due to information security concerns. Specific information on each project will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: NewElectro-Magnetic Railgun (EMRG)	0.000	0.000	7.632	0.000	7.632
Description: EMRG is a high-power, kinetic energy weapon capable of launching precision guided projectiles using electricity instead of chemical propellants. When released into the railgun, an electric pulse launches the projectile at speeds up to Mach 6. EMRG will bring new capabilities, increased capacity and improved operational economy to fleet operations at sea. With its increased velocity and extended range, the EM Railgun provides multi-mission potential for hypersonic missile defense, anti-air & surface warfare, and naval surface fire support.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602792N / *(U)Innovative Naval Prototypes(INP) Applied Res*	**Project (Number/Name)** 2481 / *EMRG*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
FY 2019 Plans: N/A ***FY 2020 Base Plans:*** Conduct applied research addressing the unique technical challenges inherent in the construction, assembly and operation of an Electro-Magnetic (EM) Railgun prototype capable of launching long range projectiles at a tactically relevant muzzle energy and repetition rate. Special materials and compact sub-system components will be developed that are capable of operating in harsh thermal and electromagnetic environments. Advanced modeling tools will be utilized to assess design options, analyze system concepts, and inform experimental hardware design and testing. Develop and test next generation pulsed power components to assess performance and applicability towards future shipboard designs. Develop and refine algorithms for controlling the precision timed electromagnetic pulse used to fire the railgun in the rep-rate mode. Conduct material, physics and thermal property research for long life, rep-rate electromagnetic launch systems and actively monitor performance to understand the high currents, elevated operating temperatures, and cooling of components, so as to improve designs and increase their reliability. Utilize modeling and simulation tools that support simulated operational scenarios to quantify the value of HVP fired from a Railgun. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase in FY 2020 is due to the realignment of the Applied Research Electro-Magnetic Railgun (EMRG) high-power, kinetic energy weapon prototype development effort from Project Unit 0000 to Project Unit 2481 within PE 0602792N.					
Accomplishments/Planned Programs Subtotals	0.000	0.000	7.632	0.000	7.632

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602792N / *(U)Innovative Naval Prototypes(INP) Applied Res*	**Project (Number/Name)** 2481 / *EMRG*

E. Performance Metrics

In all cases, the technologies being developed within this Program Element (Applied Research associated with the Innovative Naval Prototypes (INP) Program) support the Department of the Navy INP Program and are managed at the Office of Naval Research. The primary technological metrics used in this PE involve experiments and tests that demonstrate proof of concept for the technological capability being developed. Technology development is informed by periodic interaction with Naval warfighters, resource sponsors and the acquisition community. At the lowest level, each project is evaluated against technical and financial milestones on a frequent basis. Annually, each project is reviewed in depth for technical performance and development status by the Chief of Naval Research. Department of the Navy leadership is briefed on the portfolio's status by the Chief of Naval Research.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602792N / *(U)Innovative Naval Prototypes(INP) Applied Res*	Project (Number/Name) 2958 / *Cyberspace Activities*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
2958: *Cyberspace Activities*	0.000	0.000	0.000	31.003	-	31.003	28.511	26.061	0.000	0.000	0.000	85.575

Note

The FY 2017 Appropriation Act encouraged the services to realign Cyberspace Activity (CA) resources into individual cost codes, projects or program elements (PEs) in order to provide additional clarity and enhanced oversight of cyberspace resources. Within this PE, cyber funding was moved from Proj 0000 Innovative Naval Protoypes (INP) Applied Research to Proj 2958 Cyberspace Activities, which was established to isolate and identify cyberspace activities.

A. Mission Description and Budget Item Justification

This Project contains all Applied Research Innovative Naval Prototype (INP) investments that are developing new technologies for cyber warfare. Potential adversaries are investing in advanced technologies that will challenge our advantages in the critical information domain. Nation states and non-state actors seek to degrade our command and control capabilities, networks and computer systems. Cyber threats continue to grow and rapidly proliferate. Technologies developed in this R-2 Activity will enable the warfighter to take immediate, appropriate action at any time, against any desired adversary, target or network by assuring that autonomous, continuous analyses of intelligence, persistent surveillance and open information sources have, at all times, optimized the possible courses of action based on commander's guidance. Technologies within this activity will foster operational endurance and enable sustained operations and resiliency for warfighters and platforms through enhanced cyber security/protection.

This Project was formerly the Cyber R-2 Activity under Project 0000 (U)Innovative Naval Prototypes(INP) Applied Research.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: Cyber	0.000	0.000	31.003	0.000	31.003
FY 2019 Plans: N/A					
FY 2020 Base Plans: Conduct Applied Research addressing the unique technical challenges required to achieve a systematic reduction of any computing system's attack surface across all its layers of computing. Continue development of tools and techniques enabling powerful tailoring of an end-system computing environment to match the needs of deployed applications and users, removing software bloat and unused features, resulting in significantly reduced attack surface for both known and unknown vulnerabilities. Specific information on each project will be provided separately to the Congressional oversight committees.					
FY 2020 OCO Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602792N / *(U)Innovative Naval Prototypes(INP) Applied Res*	**Project (Number/Name)** 2958 / *Cyberspace Activities*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2019 to FY 2020 increase reflects the realignment of funding within this PE from Project 0000 Innovative Naval Prototypes (INP) Applied Research to Project 2958 Cyberspace Activities. The 6% increase from the FY 2019 Cyber R-2 Activity ($23.535M) in Project 0000 to $31.003M here in FY 2020 is due to Applied Research associated with the planned third phase of the TPCP project, which covers efforts to develop tools and techniques for automatically customizing a range of standard communications protocols used in closed shipboard environments, tailoring end-system network stacks to match the needs of deployed applications. Addressing this computing layer is essential for achieving total protection of Navy cyber infrastructure and drastically reducing attack surface.					
Accomplishments/Planned Programs Subtotals	0.000	0.000	31.003	0.000	31.003

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

In all cases, the technologies being developed within this Program Element (Applied Research associated with the Innovative Naval Prototypes (INP) Program) support the Department of the Navy INP Program and are managed at the Office of Naval Research. The primary technological metrics used in this PE involve experiments and tests that demonstrate proof of concept for the technological capability being developed. Technology development is informed by periodic interaction with Naval warfighters, resource sponsors and the acquisition community. At the lowest level, each project is evaluated against technical and financial milestones on a frequent basis. Annually, each project is reviewed in depth for technical performance and development status by the Chief of Naval Research. Department of the Navy leadership is briefed on the portfolio's status by the Chief of Naval Research.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602861N *I (U)Science & Tech Management - ONR Field Acts*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	65.222	64.418	73.961	-	73.961	74.791	76.130	77.437	79.089	Continuing	Continuing
0000: *(U)Science & Tech Management - ONR Field Acts*	0.000	65.222	64.418	73.961	-	73.961	74.791	76.130	77.437	79.089	Continuing	Continuing

A. Mission Description and Budget Item Justification

This Program Element (PE) is for the Office of Naval Research (ONR) to cover corporate expenses including salaries, Information Technology (IT), Financial Improvement Plan (FIP) efforts, Defense Finance and Accounting Service (DFAS) Billings, and some of the day-to-day logistical costs. The vast majority of these items represent fixed costs associated with Scientists and Engineers supporting the Navy's Science and Technology (S&T) Programs.

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	62.722	64.418	65.790	-	65.790
Current President's Budget	65.222	64.418	73.961	-	73.961
Total Adjustments	2.500	0.000	8.171	-	8.171
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	2.500	0.000			
• SBIR/STTR Transfer	-	-			
• Program Adjustments	0.000	0.000	9.150	-	9.150
• Rate/Misc Adjustments	0.000	0.000	-0.979	-	-0.979

Change Summary Explanation

The increase supports the workforce requirements necessary to support, manage, and rapidly field technology to the fleet. The increase ensures funding is available to meet the salary needs of the current Scientific Program Officers workforce, the associated staff required to support the execution of the research, and an additional 20 FTE as determined by the recent ONR workforce shaping. The announcements will be going on in 2019 to be fully staffed at the beginning of 2020.

Technical: Not applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602861N / *(U)Science & Tech Management - ONR Field Acts*	Project (Number/Name) 0000 / *(U)Science & Tech Management - ONR Field Acts*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *(U)Science & Tech Management - ONR Field Acts*	0.000	65.222	64.418	73.961	-	73.961	74.791	76.130	77.437	79.089	Continuing	Continuing

Note

N/A

A. Mission Description and Budget Item Justification

This project supports ONR leadership, management and direction for the Naval S&T program. This project funds ONR HQ Non-Management Headquarters Activities (Non-MHA) salaries, communications, and other fixed costs. ONR sponsors scientific advances, which lead to Future Naval Capabilities (FNCs), supporting the Fleet's ability to operate from a position of technological superiority. Functions performed include (1) scientific and technical direction of the nationwide 6.1 basic research program with colleges, universities, non-profit organizations and Naval Laboratories and Warfare Centers; (2) scientific and technical direction of the 6.2 applied research program through the Naval R&D laboratories and Warfare Centers and industry; (3) scientific and technical direction of the Naval 6.3 advanced technology development program through the Navy's R&D laboratories, Warfare Centers and industry; (4) management, resource formulation, program assessment, and contract negotiation/administration of the Navy basic research, applied research and advanced technology development program; and (5) coordination of the Navy's Technology Base program within the context of total DoD/Government (e.g., National Science Foundation, National Academy of Sciences) R&D initiatives in order to maximize scientific advances. This project also supports ONR Non-MHA management and direction for the following Navy-wide programs: Small Business Innovation Research, Naval Research Advisory Committee, Navy Patent Program, Historically Black Colleges and Universities/Minority Institutions Program, Navy Manufacturing Technology Program and the Ballistic Missile Submarine Nuclear (SSBN) Security Technology Program.

Additionally, this project funds ONR field salaries, communications, and other fixed costs.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: (U) Science & Tech Management - ONR Field Acts	65.222	64.418	73.961	0.000	73.961
Description: This Project provides funds for both Non-MHA Labor and Non-Labor costs associated with executing ONR's mission to discover, develop, and transition innovative science and technology (S&T) to meet current and future needs of naval forces. Most all the funds in this project are fixed costs, such as salaries and communications. Specifically, it pays the salaries of Scientific and Engineering and corporate business personnel who direct the execution of the Navy's basic research, applied research, and advanced technology development programs at the nation's universities/colleges, Navy laboratories, Warfare Centers, and private industry.					
FY 2019 Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602861N / *(U)Science & Tech Management - ONR Field Acts*	**Project (Number/Name)** 0000 / *(U)Science & Tech Management - ONR Field Acts*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
This project provides for all costs of ONR Headquarters in support of the entire Navy S&T program. Most all of the funds in this project are fixed costs, such as salaries, and communications. Specifically, it pays the salaries of Scientific and Engineering and corporate business personnel who direct the execution of the Navy's basic research, applied research, and advanced technology development programs at the nation's universities/ colleges, Navy laboratories, Warfare Centers, and private industry. This project provides for all basic costs of ONR activities in support of the entire Navy S&T program. ***FY 2020 Base Plans:*** This project provides for all costs of ONR Headquarters in support of the entire Navy S&T program. Most all of the funds in this project are fixed costs, such as salaries, and communications. Specifically, it pays the salaries of Scientific and Engineering and corporate business personnel who direct the execution of the Navy's basic research, applied research, and advanced technology development programs at the nation's universities/ colleges, Navy laboratories, Warfare Centers, and private industry. This project provides for all basic costs of ONR activities in support of the entire Navy S&T program. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase supports the workforce requirements necessary to support, manage, and rapidly field technology to the fleet. The increase ensures funding is available to meet the salary needs of the current Scientific Program Officers workforce, the associated staff required to support the execution of the research, and an additional 20 FTE as determined by the recent ONR workforce shaping. The announcements will be going on in 2019 to be fully staffed at the beginning of 2020.					
Accomplishments/Planned Programs Subtotals	65.222	64.418	73.961	0.000	73.961

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602861N / *(U)Science & Tech Management - ONR Field Acts*	**Project (Number/Name)** 0000 / *(U)Science & Tech Management - ONR Field Acts*

E. Performance Metrics

This PE funds operating costs for ONR's mission. Program performance is measured by attaining financial benchmarks for planned obligations vs. actual obligations and planned expenditures vs. actual expenditures.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603123N *I Force Protection Advanced Technology*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	52.785	32.615	35.286	-	35.286	24.410	21.723	17.080	17.423	Continuing	Continuing
2912: *Force Protection Advanced Technology*	0.000	23.051	30.192	32.839	-	32.839	21.907	19.205	14.519	14.810	Continuing	Continuing
3049: *Force Protection*	0.000	2.695	2.423	2.447	-	2.447	2.503	2.518	2.561	2.613	Continuing	Continuing
9999: *Congressional Adds*	0.000	27.039	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	27.039

A. Mission Description and Budget Item Justification

The efforts described in this Program Element (PE) are based on investment directions as defined in the Naval S&T Strategic Plan approved by the S&T Corporate Board. This strategy is based on needs and capabilities from Navy and Marine Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It provides the vision and key objectives for the essential science and technology efforts that will enable the continued supremacy of U.S. Naval forces in the 21st century. The Strategy focuses and aligns Naval S&T with Naval missions and future capability needs that address the complex challenges presented by both rising peer competitors and irregular/ asymmetric warfare.

This PE addresses advanced technology development associated with providing the capability of Platform and Force Protection for the U.S. Navy. This program supports the development of technologies associated with all naval platforms (surface, subsurface, terrestrial and air) and the protection of those platforms.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	26.342	2.423	2.447	-	2.447
Current President's Budget	52.785	32.615	35.286	-	35.286
Total Adjustments	26.443	30.192	32.839	-	32.839
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	30.192			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.557	0.000			
• Program Adjustments	0.000	0.000	32.839	-	32.839
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy				Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*		R-1 Program Element (Number/Name) PE 0603123N *I Force Protection Advanced Technology*		
• Congressional Add Adjustments	28.000	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)

	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Navy Automonous Swarmboats*	27.039	0.000
Congressional Add Subtotals for Project: 9999	27.039	0.000
Congressional Add Totals for all Projects	27.039	0.000

Change Summary Explanation

Technical: Not applicable.

Schedule: Not applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603123N / *Force Protection Advanced Technology*	Project (Number/Name) 2912 / *Force Protection Advanced Technology*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
2912: *Force Protection Advanced Technology*	0.000	23.051	30.192	32.839	-	32.839	21.907	19.205	14.519	14.810	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project addresses advanced technology development associated with providing the capability of Platform and Force Protection for the U.S. Navy. This project supports the development of technologies associated with all naval platforms (surface, subsurface, terrestrial, and air) and the protection of those platforms. For the new FY 2016 effort, Forward Deployed Energy and Communications Outpost (FDECO) Innovative Naval Prototype (INP), the project addresses advanced technology development associated with providing the undersea energy and communications infrastructure necessary to assure undersea dominance; extend the reach of undersea assets; enhance situational awareness (SA) and standoff advantage without reducing forward presence and; provide endurance for unmanned systems necessary for force multiplication in an anti-access/area denial (A2/AD) environment. For the Medium Displacement Unmanned Surface Vehicle (MDUSV), the project will radically change the way the Navy does mine influence sweep, anti-submarine warfare (ASW) and electronic warfare (EW) missions; it will introduce larger unmanned surface vehicles (USV) to the Navy; and it will introduce advanced autonomy to the surface Navy.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: SURFACE SHIP & SUBMARINE HULL MECHANICAL & ELECTRICAL (HM&E)	17.161	23.941	26.703	0.000	26.703
Description: This project addresses advanced technology development associated with providing the capability of Platform and Force Protection for the U.S. Navy. This project supports the development of technologies associated with various naval platforms (surface, subsurface and terrestrial) and the protection of those platforms. The primary research efforts within this activity are focused on advanced technology development for Unmanned Sea Surface Vehicles in support of Naval S&T Focus Area on Autonomy and Unmanned Vehicles and At-Sea Vertical Launch System rearming. Unmanned Sea Surface Vehicle (USSV) technology development includes autonomous navigation for USSVs. Also funded in this activity is the Energy System Technology Evaluation Program (ESTEP), which promotes innovation and entrepreneurial opportunities for naval personnel and student veterans through advanced technology development and demonstration projects at naval facilities and laboratories. Program goals include: advance dual-use and naval-unique technologies that increase operational capabilities and efficiencies; leverage commercial technologies and private investments to provide warfighter capability at reduced cost; and evaluate innovative technologies from naval laboratories and startup companies.					
FY 2019 Plans: Conduct advanced research related to critical S&T for development of autonomous navigation for Unmanned Sea Surface Vehicles from host ship. Expand research for conducting advanced technology demonstrations					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603123N / *Force Protection Advanced Technology*	**Project (Number/Name)** 2912 / *Force Protection Advanced Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
to evaluate innovative energy technologies using Navy and Marine Corps facilities as test beds. Perform non-recurring engineering, modeling and fabrication necessary for a prototype and demonstration of At-Sea Rearm of Vertical Launch System (VLS) capability in a relevant environment during FY22. ***FY 2020 Base Plans:*** - Conduct advanced research related to critical S&T for development of autonomous navigation for Unmanned Sea Surface Vehicles from host ship. - Continue ESTEP project efforts, including assessment of advanced energy technologies; development of cyber-physical security for energy networks; and utilization of autonomous systems, artificial intelligence and advanced manufacturing to address operational challenges in logistics and readiness. - Continue efforts for prototype and operational FY22 demonstration of At-Sea Rearm of Vertical Launch System (ASRV) capability in a relevant environment including crane, mooring system, strike-up/strike-down system fabrication and testing. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increase from FY 2019 to FY 2020 includes additional investment to support preparation for prototype and operational FY 2022 demonstration of At-Sea Rearm of Vertical Launch System capability.					
Title: AIRCRAFT TECHNOLOGY	5.890	6.251	6.136	0.000	6.136
Description: The Aircraft Technology activity develops technologies for enhanced capability of Naval aviation aircraft platforms in terms of mission effectiveness, platform range, responsiveness, survivability, observability, readiness, safety and life cycle cost. It also develops new Naval air vehicle concepts and high impact, scalable Naval air vehicle technologies, such as - autonomous air vehicle command and control, helicopter and tiltrotor rotor drive systems, aerodynamics, propulsion systems, materials, structures and flight controls for future and legacy air vehicles. This activity directly supports the Naval Research and Development Framework, principally in the Autonomy and Unmanned Systems, Platform Design and Survivability, Power and Energy and Total Ownership Cost Focus Areas. ***FY 2019 Plans:***					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603123N / *Force Protection Advanced Technology*	**Project (Number/Name)** 2912 / *Force Protection Advanced Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Conduct advanced technology development efforts and demonstrations of the Variable Cycle Advanced Technology (VCAT) Program. Critical technology development efforts continue with major engine manufactures and system contractors to develop/mature the highest priority, long lead propulsion system technologies, including variable/adaptive cycle engine components, for next generation carrier based Tactical Air (TACAIR) Intelligence, Surveillance and Reconnaissance (ISR) systems. ***FY 2020 Base Plans:*** Conduct advanced technology development efforts and demonstrations of the Variable Cycle Advanced Technology (VCAT) Program which will enable the Navy's Next Generation Air Dominance (NGAD) carrier aircraft. Critical technology development efforts continue with major engine manufacturers and to develop/ mature the highest priority, long lead propulsion system technologies, including variable/adaptive cycle engine controls, variable area turbines, Ceramic Matrix Composites (CMC), Polymer Matrix Composites (PMC), and Integrated Propulsion, Power and Thermal Management Systems (IPPTMS) architectures and technologies. These efforts will support the Navy's planned NGAD Technology Maturation and Risk Reduction program for the engine design and development, and Integrated Propulsion, Power and Thermal Management System. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** No significant change between FY 2019 and FY 2020					
Accomplishments/Planned Programs Subtotals	23.051	30.192	32.839	0.000	32.839

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

The overall goals of this advanced technology program are the development of technologies which focus on the warfighter and providing the ability to win or avoid engagements with other platforms or weapons and, in the event of engagement, to resist and control damage, while preserving operational capability. Overall metric goals are to transition the advanced technology projects into acquisition programs. Each Activity within this PE has unique goals and metrics, some of which include

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603123N / *Force Protection Advanced Technology*	**Project (Number/Name)** 2912 / *Force Protection Advanced Technology*

classified quantitative measurements. Specific examples of metrics under this PE include: - Advanced technology demonstrations to evaluate emerging energy technologies.

For the Forward Deployed Energy and Communications Outpost (FDECO) Innovative Naval Prototype (INP) effort, the overall goals is the development of technologies which focus on energy management and transfer technologies that enable persistent undersea operations by unmanned vehicle (UV) Fleet; provide system architectures that are persistent, scalable and mission agile; provide communication and energy infrastructure available in degraded and contested environments and; provide a platform-agnostic solution that reduces development and maintenance costs. Overall metric goals are to transition the key advanced technology elements, Forward Deployed Energy (FDE), Forward Deployed Communications (FDC) and Forward Deployed Docking (FDD) into acquisition programs. Each Activity within this PE has unique goals and metrics, some of which include classified quantitative measurements. Specific examples of metrics include: - Advanced technology demonstrations to evaluate energy and data transmission and persistent connectivity.

Medium Displacement Unmanned Surface Vehicle (MDUSV), the objectives are to 1) Demonstrate, using specific payloads, the multi-mission versatility of MDUSV, and identify key interface requirements for future payloads; 2) Provide a robust assessment of MDUSV's collision regulations (COLREGs) autonomy to build confidence in the reliability and safety of the autonomous control system; and 3) Enable the evaluation of MDUSV's operational utility and design to support an acquisition transition decision.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603123N / *Force Protection Advanced Technology*				Project (Number/Name) 3049 / *Force Protection*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
3049: *Force Protection*	0.000	2.695	2.423	2.447	-	2.447	2.503	2.518	2.561	2.613	Continuing	Continuing

A. Mission Description and Budget Item Justification

Develop advanced technologies, critical to protecting naval installations, to provide seamless full spectrum protection against asymmetric attack by improving the ability to: detect and identify developing and immediate threats; shape our responses through improved situational awareness and decision making; shield personnel, mission critical facilities, infrastructure, and operating fleet assets; maintain essential functions; and sustain and restore critical services in the aftermath of an incident. Technologies developed will also seek to reduce the required manpower and skill levels devoted to the force protection mission.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: EMERGING THREATS	2.695	2.423	2.447	0.000	2.447
Description: This activity includes development of advanced technologies critical to protecting naval installations, and will provide seamless, full spectrum protection against asymmetric terrorist attack by improving the ability to: sense developing and immediate threats; shape our responses through improved situational awareness and decision making; shield personnel, mission critical facilities, infrastructure, and operating fleet assets; maintain essential functions; and sustain and restore critical services in the aftermath of an incident. Technologies developed will also seek to reduce the required manpower and skill levels devoted to the force protection mission. ***FY 2019 Plans:*** Complete development and conduct full demonstration of Virtual Inductive Loop technology to include automated perimeter surveillance in the region of the entry control point. Replacing in ground inductive loops with video based virtual inductive loops will improve reliability and performance and reduce maintenance costs associated with Naval Facilities Engineering Command (NAVFAC) automated gates. Ongoing development of Autonomous Maritime Asset Protection capabilities for detection, classification, and defeat of small unmanned air, surface, and subsurface threats to naval installations through fusion of electro-optic sensors, acoustic sensors and countermeasures technologies demonstrated under this program. ***FY 2020 Base Plans:*** Continue development, and conduct interim demonstration, of the Autonomous Maritime Asset Protection System (AMAPS) capability including integration of unmanned response technologies. Develop capability to detect and counter small unmanned underwater vehicles (C-UUV) in the harbor environment and integrate into					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603123N / *Force Protection Advanced Technology*	**Project (Number/Name)** 3049 / *Force Protection*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
AMAPS. Develop technologies to detect and counter small unmanned air threats within the constraints and parameters associated with Commander Naval Installations (CNIC) and NAVFAC requirements. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Accomplishments/Planned Programs Subtotals	2.695	2.423	2.447	0.000	2.447

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

The overall goal of this program is to develop technologies which will provide protection for our naval installations against asymmetric attack. Specific metrics include: a 50% reduction of manpower required to perform force protection surveillance, situational awareness, and decision making, a 2x improvement in electro-optical sensor performance in adverse weather conditions, a 50% reduction in sensor cost per square or cubic meter of detection at a given resolution, and a 50% reduction in false alarm rates for automated detection and tracking algorithms both on, above and below water.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603123N / *Force Protection Advanced Technology*	Project (Number/Name) 9999 / *Congressional Adds*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	27.039	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	27.039

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Navy Automonous Swarmboats	27.039	0.000
FY 2018 Accomplishments: Funding used to execute further research and support for Navy Autonomous Swarmboats, including multi-unmanned surface vehicle (USV) autonomous operations.		
FY 2019 Plans: N/A		
Congressional Adds Subtotals	27.039	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other Projects.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603271N *I Electromagnetic Systems Advanced Technology*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	9.231	8.804	9.499	-	9.499	8.008	8.169	8.336	8.503	Continuing	Continuing
2913: *Electromagnetic Systems Advanced Technology*	0.000	9.231	8.804	9.499	-	9.499	8.008	8.169	8.336	8.503	Continuing	Continuing

A. Mission Description and Budget Item Justification

The activities described in this PE address future Navy and Marine Corps capabilities needed to maintain maritime superiority and ensure national security. They are based on input from Naval Research Enterprise stakeholders (including the Naval enterprises, the combatant commands, OPNAV and Headquarters Marine Corps) and are designed to exploit breakthroughs in science and technology in order to deliver maximum warfighting benefit to our sailors and marines. These efforts are aligned with shared priorities throughout the whole of RDT&E in order to quickly advance new capabilities from discovery to deployment across the warfighting domains.

Activities and efforts in this PE address technologies critical to enabling the transformation of discrete functions to network centric warfare capabilities, which simultaneously perform Radar, Electronic Warfare (EW), and Communications and Network functions across platforms through multiple, simultaneous and continuous communications/data links. The Electromagnetic Systems Advanced Technology program addresses Radio Frequency (RF) technology for Surface and Aerospace Surveillance sensors and systems, EW sensors and systems, RF Communication Systems, Multi-Function sensor systems, and Position, Navigation and Timing (PNT) capabilities. Within the Naval Transformational Roadmap, this investment offers affordable options for the transformational capabilities required by the Sea Shield (Theater Air and Missile Defense), Sea Strike (Persistent Intelligence, Surveillance, and Reconnaissance), and ForceNet (Communications and Networking) SeaPower 21 Naval Warfighting Pillars.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	9.360	0.000	0.000	-	0.000
Current President's Budget	9.231	8.804	9.499	-	9.499
Total Adjustments	-0.129	8.804	9.499	-	9.499
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	8.804			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.117	0.000			
• Program Adjustments	0.000	0.000	9.499	-	9.499
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603271N *I Electromagnetic Systems Advanced Technology*

• Congressional General Reductions Adjustments	-0.012	-	-	-	-

Change Summary Explanation

The change from FY19 to FY20 reflects increased investment in Global Positioning System (GPS) and Navigation Technology.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603271N / *Electromagnetic Systems Advanced Technology*				Project (Number/Name) 2913 / *Electromagnetic Systems Advanced Technology*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
2913: *Electromagnetic Systems Advanced Technology*	0.000	9.231	8.804	9.499	-	9.499	8.008	8.169	8.336	8.503	Continuing	Continuing

A. Mission Description and Budget Item Justification

Work in this project addresses cost-effective Radio Frequency (RF) technology for Surface and Aerospace Surveillance sensors and systems, Electronic Warfare (EW) sensors and systems, RF Communication Systems, Multi-Function sensor systems, and Position, Navigation and Timing (PNT) capabilities.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: ELECTRONIC AND ELECTROMAGNETIC SYSTEMS	5.169	4.204	4.180	0.000	4.180
Description: The overarching objective of the Electronic and Electromagnetic Systems Activity is to develop, test, and demonstrate Communications, Electronic Attack (EA), Electronic Surveillance (ES), Electronic Warfare (EW), and Radar functions. A portion of this PE is devoted to mid-term technology development in close concert with acquisition programs of record. The products of these efforts are planned for transition at the end of their schedule into the associated acquisition program of record. Major thrust within the Electronics and Electromagnetic Systems program are: a) Advanced EW Enabling Technologies - Develop classified advanced electronic warfare technology in support of current and predicted capability requirements. ***FY 2019 Plans:*** Continue research in the areas of improved threat warning systems; electronic warfare support (ES); decoys and countermeasures against weapon tracking and guidance systems; electronic attack (EA) against adversary command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR); and electronic protection (EP) of our own weapons and C4ISR from intentional and unintentional interference to control the electromagnetic spectrum (EMS) by exploiting, deceiving, or denying enemy use of the spectrum while ensuring its use by friendly forces. ***FY 2020 Base Plans:*** COnduct research in the areas of improved threat warning systems; electronic warfare support (ES); decoys and countermeasures against weapon tracking and guidance systems; electronic attack (EA) against adversary command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR); and electronic protection (EP) of our own weapons and C4ISR from intentional and unintentional interference to					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603271N / *Electromagnetic Systems Advanced Technology*	**Project (Number/Name)** 2913 / *Electromagnetic Systems Advanced Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
control the electromagnetic spectrum (EMS) by exploiting, deceiving, or denying enemy use of the spectrum while ensuring its use by friendly forces. Refine design of and implement next-generation electronic warfare development and evaluation capability for the Navy (classified details available). Employ the updated capability for real-world assessments of existing electronic warfare and sensor system performance. Conduct analysis of results of FY19 test and evaluation activities. Refine and modify designs based on results, and initiate implementation of modified and additional capabilities. Continue close coordination with associated S&T and acquisition programs. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** No significant change between FY 2019 and FY 2020					
Title: GLOBAL POSITIONING SYSTEM (GPS) & NAVIGATION TECHNOLOGY	4.062	4.600	5.319	0.000	5.319
Description: The overarching objective of this activity is to develop technologies that enable the development of affordable, effective and robust Position, Navigation and Timing (PNT) capabilities using either GPS systems, non-GPS navigation devices, or atomic clocks. This activity will increase the operational effectiveness of U.S. Naval units. The focus is on the mitigation of GPS electronic threats, the development of atomic clocks that possess unique long-term stability and precision, and the development of compact, low-cost, Inertial Navigation Systems (INS). The following are non-inclusive examples for projects funded in this activity. As a result of a comprehensive DOD wide assessment of current S&T investments in the area of Position, Navigation and Timing, there has been increased investment in the Global Positioning System (GPS) & Navigation Technology thrust for Assured Time Dissemination research. ***FY 2019 Plans:*** Conduct advanced research and development in position, navigation and timing. This research aims to develop devices and systems that provide assured, cost-effective, and mission relevant PNT to the warfighter. Areas of investment included robust GPS, non-GPS navigation aids, and assured timekeeping. Specifically, research that enables robust integrity checking and monitoring of GPS in the presence of electronic threats and anti-spoofer/ anti-jam processors for the purpose of providing precision navigation capabilities in the presence of emergent threats; atomic clocks that possess unique long-term stability and precision for the purpose of providing GPS-independent precision time as well as time-transfer techniques for the purpose of providing GPS-independent					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603271N / *Electromagnetic Systems Advanced Technology*	**Project (Number/Name)** 2913 / *Electromagnetic Systems Advanced Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
precision time; and Inertial navigation systems for the purpose of providing an alternative means of providing precision navigation, correlation navigation technique using high precision earth maps, for those Naval platforms which may not have GPS navigation capabilities and/or loss of GPS signals. ***FY 2020 Base Plans:*** Conduct advanced research and development in position, navigation and timing. This research aims to develop techniques and technology to provide assured, cost-effective, and mission relevant PNT to the warfighter. Areas of investment included robust GPS, non-GPS navigation aids, and assured timekeeping. Specifically, GPS Anti-Jam Antennas and Receivers for Navy platforms for the purpose of providing precision navigation capabilities in the presence of electronic threats and anti-spoofer/anti-jam processors for the purpose of providing precision navigation capabilities in the presence of emergent threats; Tactical grade atomic clocks that possess unique long-term stability and precision for the purpose of providing GPS-independent precision time and transferring UTC(USNO) time via alternative electromagnetic links for the purpose of providing GPS-independent precision time; and Inertial navigation systems for the purpose of providing an alternative means of providing precision navigation, a correlation navigation technique using earth maps of high precision, for those Naval platforms which may not have GPS navigation capabilities and/or loss of GPS signals. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increase from FY 2019 and FY 2020 is for increased investment in Assured Time Dissemination research in the Global Positioning System (GPS) and Navigation Technology thrust. This increase comes as a result of a comprehensive DOD wide assessment of current S&T investments in the area of Position, Navigation and Timing.					
Accomplishments/Planned Programs Subtotals	9.231	8.804	9.499	0.000	9.499

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603271N / *Electromagnetic Systems Advanced Technology*	**Project (Number/Name)** 2913 / *Electromagnetic Systems Advanced Technology*

E. Performance Metrics

Advanced Electronic Sensor Systems for Missile Defense and Long Range Detection and Tracking ECs are aligned to the Navy's Advanced Cruiser (CG(X)) plans and closely coordinated with Naval Sea Systems Command Integrated Warfare Systems (PEO IWS 2.0). Other performance metrics are discussed within the R-2a. Navigation and timekeeping developments are aligned and coordinated to the OPNAV (N2N6E4) Assured PNT plan for surface and aviation platforms and with the Special Programs office's technology development roadmap.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603640M *I MC Advanced Technology Demo*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	164.992	174.809	172.847	-	172.847	168.520	171.906	175.319	178.826	Continuing	Continuing
2223: *Marine Corps ATD*	0.000	94.567	100.979	95.327	-	95.327	98.263	100.313	102.326	104.373	Continuing	Continuing
2297: *Futures Directorate*	0.000	58.354	46.830	73.046	-	73.046	65.781	67.116	68.427	69.796	Continuing	Continuing
2958: *Cyberspace Activities*	0.000	0.000	0.000	4.474	-	4.474	4.476	4.477	4.566	4.657	Continuing	Continuing
9999: *Congressional Adds*	0.000	12.071	27.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	39.071

A. Mission Description and Budget Item Justification

This Program Element (PE) addresses demand signals emphasized by the Commandant of the Marine Corps, the Chief of Naval Operations, and the Chief of Naval Research, as well as those pulled from dynamic engagement with stakeholders. Research efforts are carefully selected to ensure they have the potential to expand warfighting capabilities, inform operational concepts and requirements development, and advance state of the art technology and scientific knowledge. Current guidance also highlights the need to accelerate our pace of development and guide the approach to rapid experimentation, prototyping, and learning.

As reflected in the Marine Corps Operating Concept, the current strategic guidance from the Commandant, expeditionary forces will conduct maneuver warfare in environments characterized by complex terrain, technology proliferation, information used as a weapon, a battle of signatures, and an increasingly contested maritime domain. Additionally, an emergent operation stressor is the contested urban environment which exemplifies the characterizations listed above. The urban environment is one of the most complex terrains with physical compartmentalization and canalization, additional physical dimensions (subterranean and multi-story structures), crowded conditions and associated threat obscuration, communications challenges, informational and human aspects, and proliferation of observation and fires technologies. This environment requires capabilities addressing all the activities within this PE and while it provides many challenges, unique opportunities are also presented and can further shape technology approaches.

These future challenges and portents demand robust technologies for the Marine Corps, but the technology options are constrained. They must have a lightweight deployable character, and the ability to operate in austere conditions with little fixed infrastructure or support while retaining the agility and lethality of an integrated maneuver force. Technology must provide full spectrum capability against robust and complex peer and near-peer adversaries while meeting Size, Weight, Power, Cost limitations, and information availability within Distributed, Intermittent and Limited environments.

The approach within this PE encompasses ideas that support both revolutionary and evolutionary capabilities, and in this way considers and balances both "push" and "pull" aspects of technology projects. This PE matures technologies emerging from PE 0602131M-Marine Corps Landing Force Technology to develop concept prototypes and initial experimentation to confirm feasibility in an environment relavent to operations.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603640M *I MC Advanced Technology Demo*

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	154.407	150.245	142.377	-	142.377
Current President's Budget	164.992	174.809	172.847	-	172.847
Total Adjustments	10.585	24.564	30.470	-	30.470
• Congressional General Reductions	-	-0.436			
• Congressional Directed Reductions	-	-2.000			
• Congressional Rescissions	-	-			
• Congressional Adds	-	27.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	4.073	0.000			
• SBIR/STTR Transfer	-3.792	0.000			
• Program Adjustments	0.000	0.000	30.470	-	30.470
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
• Congressional General Reductions Adjustments	-0.296	-	-	-	-
• Congressional Directed Reductions Adjustments	-1.900	-	-	-	-
• Congressional Add Adjustments	12.500	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Program Increase*	12.071	0.000
Congressional Add: *Common Unmanned Aerial Vehicle Simulation System*	0.000	10.000
Congressional Add: *Flight Motion Simulator and Testing of UAVs*	0.000	6.000
Congressional Add: *Modular Advanced Armed Robotic System 2.0*	0.000	4.000
Congressional Add: *UAS Air-Delivered Extended Range Munitions Demo*	0.000	7.000
Congressional Add Subtotals for Project: 9999	12.071	27.000
Congressional Add Totals for all Projects	12.071	27.000

Change Summary Explanation

Major program adjustment is associated with a one-time $15M increase in FY20 in order to enhance Intelligence, Surveillance, and Reconnaissance (ISR) capabilities. Will initiate efforts to receive, transmit, and fuse joint asset specialized sensor information to communications nodes afloat and ashore via an aerial

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603640M *I MC Advanced Technology Demo*

gateway. Additional $10M in FY20 and subsequent across the FYDP to fund Marine Corps Science and Technology in-line with Office of the Secretary of Defense (OSD) steady-state guidance. Efforts are justified in Project 2297.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / *MC Advanced Technology Demo*	Project (Number/Name) 2223 / *Marine Corps ATD*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
2223: *Marine Corps ATD*	0.000	94.567	100.979	95.327	-	95.327	98.263	100.313	102.326	104.373	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project funds technology demonstration, experimentation, and prototyping; and more technologically mature projects within the Future Naval Capability (FNC) process as means to inform, enhance, enable, and invent future concepts and capabilities with new S&T. This project is organized into ten activities, the core of which is represented by the eight Expeditionary Warfighting Capability Areas.

Emphasized within this project are increased efforts to actively demonstrate advanced technologies and system concepts. These demonstrations and experiments focus on the specific technologies, not necessarily their operational application, and vary based on the technical maturity of the project. This early technology exposure gives Marines a view into the future and enables them to use their imagination and innovation to envision novel employment of the technology and inform the acquisition process.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: COMMAND, CONTROL, COMMUNICATIONS, COMPUTERS (C4)	7.420	6.480	10.000	0.000	10.000
Description: This activity investigates robust, resilient, and secure networked communications pathways and capability that support an expeditionary force's distributed and disaggregated operations. Research supports both networked and local computation for communications that exploits the expeditionary forces close physical proximity to threats while mitigating shortfalls commiserate within Distributed, Intermittent, and Limited environments. Expeditionary forces must operate in the cyber domain and in addition to defending communications networks, vehicles, and weapons systems, are reliant on electronic controllers for basic operations and as such are susceptible to cyberattacks. Technologies addressed within this activity include secure, robust, self-forming, mobile communications networks; distributed computing to support information dissemination to all echelons; improved capabilities in over-the-horizon, beyond line-of-sight, and restricted environment communications and sensors; and software and data processing to support formation of an appropriate common picture. Other efforts include power management, low detectability, conforming to Size, Weight, Power, Cost constraints, and interoperability within the joint environment. Further, this activity integrates and demonstrates enhanced communications and situational awareness capabilities in experimental and warfighting environments reflecting USMC operations. Advanced technology resources will be developed and applied to complement commercial, other service, and defense agency					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
investments to produce a technology base addressing identified Marine Corps technology gaps. Focus will be on developing component level prototypes and experimentation in relevant environments. ***FY 2019 Plans:*** The Command, Control, Communications and Computers (C4) research effort focuses heavily on the continued development and integration of multiple underlying technologies into subsystems and system with the purpose of demonstrating the tactical exploitation of information and the electromagnetic spectrum. To address resiliency requirements,C4 is coordinating closely with Expeditionary Cyber to address resiliency requirements by efficiently exploiting multifunction capabilities in portable and reduced Size, Weight, Power, and Cost systems. Other efforts include power management, low detectability, and interoperability within the joint environment This integrated rapid co-design, prototyping, and experimentation approach will reduce time needed to provide new capabilities to the US Marine Corps. Developed and demonstrated technologies will include signature management, interoperability, spectrum maneuver, damage assessment monitoring, and information dominance for tactical edge systems. ***FY 2020 Base Plans:*** The C4 and Electronic Warfare research effort focuses heavily on the continued development and integration of multiple underlying technologies into subsystems and system with the purpose of demonstrating the tactical exploitation of information and the electromagnetic spectrum. To address resiliency requirements of C4 this effort is closely coordinated with the Intelligence, Surveillance, and Reconnaissance and Expeditionary Cyber research portfolio also described herein so as to most efficiently exploit multifunction capabilities in portable reduced Size, Weight, Power, Cost systems. This integrated rapid co-design, prototyping, and experimentation approach will reduce time needed to provide new capabilities to the US Marine Corps. Developed and demonstrated technologies will include advanced signature management, interoperability, machine learning, spectrum maneuver, damage assessment monitoring, and information dominance for tactical edge systems. Additional emphasis of operating in the challenging warfighter electromagnetic spectrum environment is addressed in the multifunction electronic warfare domains. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:***					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
The increase from FY 2019 to FY 2020 is associated with greater emphasis on deception and signature management.					
Title: FIREPOWER	8.734	16.955	9.000	0.000	9.000
Description: The activity investigates a large variety of weapons to provide the warfighter with a decisive, yet surgical, tactical advantage to collectively address 21st-century combined-arms warfare against peer and near-peer states. Research efforts increase the reach, lethality and capacity, while retaining mobility and tempo beneficial to expeditionary maneuver warfare. Maintaining focus on Size, Weight, Power, Cost and Distributed, Intermittent and Limited environments stresses the technical solutions available. This activity furthers the maturity of researched technology solutions by also developing the integration required to effectively demonstrate and test emergent capabilities. Achieving a true combined arms state involves a full systems approach for both kinetic and non-kinetic capabilities all driven by a holistic targeting capability. This activity develops technology for application on current and future expeditionary weapons and elements of the kill chain. It includes, but is not limited to, the following technologies: fuze, fire control, targeting, launch/ propulsion, lethality, and accuracy. ***FY 2019 Plans:*** This activity will finalize development of direct electrical ignition for caseless small caliber ammunition for integration and testing. Development of fuzing and sensor technologies for cannon-delivered area effects munitions will continue. Systems engineering of supervised-autonomous weapon system control will continue, implementing engagement logic, to develop and demonstrate the key enabling technologies and command and control methods for weaponized unmanned ground vehicles. Efforts will include prototype weapon systems for technical evaluation. ***FY 2020 Base Plans:*** Finalize development of caseless small caliber ammunition: development of fuzing and sensor technologies for cannon-delivered area effects munitions, and development of supervised-autonomous weapon system control technologies for weaponized unmanned ground vehicles. Munitions developments will focus on low cost, extended range, precision munitions with improved lethality warhead payloads for use against stationary and moving targets on land and water, in satellite and network denied environments. ***FY 2020 OCO Plans:***					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The decrease from FY 2019 to FY 2020 is associated with one time increase in FY19 for the HR DPICM Replacement in the amount $8.6M.					
Title: FORCE PROTECTION ***Description:*** This activity investigates new ways and means to protect forces and materiel across all operational settings, from contested sea-land surface interfaces to complex urban environments. The portfolio protects against adversaries' challenges such as guided-rockets and missiles, mobile coastal artillery, threat Electronic Warfare and counter Intelligence, Surveillance and Reconnaissance. Mines and obstacles both in the water and ashore also complicate amphibious landings. The activity invests in vehicle survivability aspects that are exacerbated due to Size, Weight, Power Cost constraints inherent to Marine Corps operation and the harsh nature of the amphibious environment. Technologies addressed include lightweight armor for ballistic and underbody blast protection, advanced sensors for counter tactical surveillance, active protection, and signature management. This activity also considers technology for payloads, packages and sensors that are needed by amphibious vehicles (both manned and unmanned) including mine counter measures; explosive hazard defeat systems; and obstacle and threat detection systems as well as technologies for improved protection for individuals against blast, ballistic and blunt impact threats. ***FY 2019 Plans:*** FY 2019 Plans are focused on efforts to integrate and fuse sensor modalities while experimenting with the effectiveness of automated target recognition algorithms in high clutter environments at high speed over off-road terrains. Work will emphasize signature management of vehicle systems and integrating the knowledge of our own susceptibility, intelligence estimates of threat capabilities, and in situ data to enhance situational awareness. Focus is also on lightweight protection systems in the area of active protection that provide hemispherical coverage while reducing the threat to dismounted forces. Complete efforts associated with development of Passive Armor capabilities. Last, research is being conducted on modular, scalable, integrated stand-off Radio Frequency based explosive hazard (Improvised Explosive Devices & Mines) detection system that can be operated as a remote or autonomous system. ***FY 2020 Base Plans:***	10.422	10.794	13.415	0.000	13.415

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
FY 2020 Plans emphasize development of miniaturized hardware systems for the detection of threats across a variety of sensing modalities to take advantage of unique susceptibilities of threat systems at significant ranges. Leveraging these sensor systems, there will be development of computer vision and machine learning approaches for automated target recognition within these innovative sensing modalities. There will be development of feature extraction of threats leveraging RF based 3D buried object detection. Signature reduction materials and sensor hardware for pre-shot detection of ambush threats and surveillance will be demonstrated on platforms to evaluate enhanced survivability. Efforts will also include tactical decision aids that provide vehicle susceptibility assessment and route planning recommendations. Additionally, technologies and systems supporting the neutralization of threat systems via kinetic and non-kinetic means, to include unmanned aerial vehicles, will be developed. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase from FY 2019 to FY 2020 is associated with greater emphasis on mine countermeasures and counter-unmanned aerial systems activities.					
Title: HUMAN PERFORMANCE, TRAINING & EDUCATION	6.618	6.107	5.300	0.000	5.300
Description: This activity investigates two technology investment areas, warrior resilience, and decision-making and expertise development. Warrior resilience is focused on advanced training technologies and methodologies that enhance neural, cognitive, and physical readiness. Decision making and expertise development accelerates the development and improves the retention of skills in decision making, situation awareness, and individual and team adaptability and coordination on decentralized, dynamic and dispersed battlefields. Focus will be on developing component level prototypes for Marines to evaluate and experiment with. ***FY 2019 Plans:*** Rapid advances in wearable and human performance related technologies have provided the opportunity to demonstrate the utility of these technologies with Marine Corps populations to increase physical readiness and reduce injuries. The increased use of simulation-based training capabilities such as augmented reality offer the possibilities to demonstrate new capabilities, such as 3-Dimensional (3D) visualization, that will accelerate and increase decision making. Efforts will support hardware, software, data collection and demonstrations to support increase decision making and expertise development and warrior resilience. ***FY 2020 Base Plans:***					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Conduct research in wearable physiological monitoring, predictive algorithms, health tracking capability, and related technologies will provide the opportunity to integrate with Marine Corps' 'Force Fitness Division' programs in support of close combat formations and populations, in order to increase physical readiness and reduce potential injuries. The use of these 'Warrior Resilience' programs may be demonstrated as integral elements of larger, multipurpose exercises focused on all aspects of military tasks, or as stand-alone events where the primary purpose is to illustrate the capability to achieve improved awareness of the physical and physiological readiness of the individual. The advance of augmented reality devices and the content available for collection and display, and each of their contribution to simulation-based training (and the increased decision-making ability that this training can afford) will provide the opportunity to demonstrate 3D terrain visualization, battlefield control measures and effects, and target identification and classification. This robust and ever increasing capability will be incorporated into demonstration opportunities at ever-increasing levels of complexity and scale to demonstrate the increased decision making efficiency - in both speed and accuracy of information processing across the plan, execute, and debrief spectrum of operations. Demonstrations will include advances in hardware, software, collection and display capabilities that will support increased decision making and expertise development and warrior resilience. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The decrease from FY 2019 to FY 2020 is associated with de-emphasis on custom wearable components in force fitness.					
Title: INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE (ISR)	7.868	8.460	8.400	0.000	8.400
Description: This activity investigates enhanced situational awareness, persistent surveillance, and tactical decision making through automated analysis of data and rapid integration of information and acquired knowledge. Specific technologies in this activity effectively present actionable information to decision-makers, especially those at the lower command levels. This includes biometric monitoring for expeditionary operations, operational Course of Action development, and autonomous surveillance in support of distributed operations. Further, this activity supports the demonstration of technologies to enhance situational awareness and tactical decision making through automated analysis, fusion of data, rapid integration of information, and acquired knowledge resulting in actionable intelligence at the lower command levels. The activity includes the					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
demonstration of ISR efforts involving enhanced reconnaissance and persistent surveillance, and sensors for unmanned ground and aerial vehicles. Advanced technology demonstrations also include the collection of information [monitoring, sensing, and locating] in the 3-Dimensional urban battlespace as well as exploiting information [identifying and classifying data] as part of the intelligence preparation of the battlespace in order to facilitate operational maneuver and distributed operations. ***FY 2019 Plans:*** This activity will begin to divest investments in approximate computing for power efficiency. Research and develop prototype systems for machine question answering capabilities and in automating machine generation of complex standard military information based products. Investments are also continuing in experimentation and demonstration in artificial intelligence relevant to decision support and sensor autonomy. Increased focus will be put on investments in technology to enable all sensors, weapons, platforms to be smarter and more capable of knowing why, when and how to collaborate. ***FY 2020 Base Plans:*** Conduct assessment of the operational utility of natural language processing and computer vision. Show operational relevance of computer vision as an autonomy enabler. Increase emphasis on the production of synthetic data useful to train decision aids. Accelerate deep learning enabled data fusion. Mature algorithms capable of analyzing signatures and signature changes from graph data. Initiate development of deep learning architecture enablers including dynamic graph stores and workflow managers for models. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: USMC FUTURE NAVAL CAPABILITIES	27.487	26.885	26.849	0.000	26.849
Description: This R-2 Activity addresses the advanced technology development associated with the Marine Corps' participation in the Department of the Navy's (DoN) Future Naval Capabilities (FNC) Program. The objective of the work in this PE is to develop promising technologies emerging from the FNC technology candidates funded in PE 0602131M that have been matured to higher Technology Readiness Levels (TRLs). Investments in this activity are coordinated with similar and non-duplicative efforts in PE 0603673N. The FNC Program was restructured for FY19 to accelerate transition to the Fleet and Force. This restructuring involved a zero based review of all ongoing FNC projects, where each effort was assessed for its technology maturity and					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total

transition commitment. Ongoing efforts were categorized as FNCs or Technology Candidates. Some efforts were terminated and others were accelerated to achieve the goals of the restructured program. Funding for FNCs, which have higher Technology Readiness Levels (TRLs of 4/5 to 6) and transition funding commitments, is being resourced in this PE. Funding for FNC technology candidates at lower TRLs (3 to 4) is being resourced in PE 0602131M. ONR is working closely with the Resource Sponsors and acquisition stakeholders to develop high priority technological capabilities needed by the operational forces.

Prior to FY19, FNC Program investments were selected almost two years in advance of execution. It was determined by Navy and Marine Corps leadership that this approach limits DON's ability to exploit technology advances and respond quickly to naval needs. As a result, future BA 3 investments supporting the FNC Program are now made less than one year before commencing execution. Because FNCs are now starting at higher TRLs, the typical duration of an FNC has been shortened to 3-years. The FNC Program has been fully restructured in favor of a more direct and higher level of collaboration. Individual R-2 Activities have been discontinued and investments are organized to enhance collaboration with the acquisition stakeholders and their resource sponsors. A complete accounting of the technologies being developed and a full disposition of each technology development effort will be provided separately to the Congressional oversight committees.

FY 2019 Plans:
The advanced technologies being developed under this R-2 Activity include, but are not limited to, those that focus on developing promising technologies emerging from the FNC Applied Research program that have been matured to a Technology Readiness Level (TRL) of 4 to 5 in the areas of asymmetric and irregular warfare, distributed operations, information dominance, maneuverability, survivability, self-defense and expeditionary warfare.

FY 2020 Base Plans:
The advanced technologies being developed under this R-2 Activity focus on developing promising technologies emerging from the FNC Applied Research program that have been matured to a Technology Readiness Level of 4 to 5. Technologies being developed include, but are not limited to, those that increase target prosecution speed and accuracy against enemy firing positions by compressing the kill chain timeline through sensor fusion, Command and Control integration, and automated collaboration of warfighting functions, those that will enhance mobility, propulsion, autonomy, weapons, materials, logistics, vehicle architectures, and Electronic Warfare protection for a light armored vehicle fleet, technologies associated with the development of an affordable, longer range mortar projectile, with precision delivery against stationary and moving targets during periods of full Global

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Positioning Satellite denial, technologies that optimize the balance between hardening and flexible software development for future dynamic engagements in contested environments with adversaries, and new repair techniques to include the use of solid-state technologies such as cold-spray and additive friction stir welding for structural repairs. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: LOGISTICS	7.942	9.553	7.837	0.000	7.837
Description: This activity investigates the practical discipline and real world application of the deployment, sustainment, reconstitution, and re-deployment of forces engaged in expeditionary operations. Logistics replaces mass with assured knowledge and speed, is equally capable ashore or afloat in austere environments, and is fully scalable to meet uncertain requirements. This includes efficient and responsive force sustainment, planning and directing logistics operations, logistics demand reduction, fleet maintenance, and expeditionary energy. Expeditionary Energy enhances combat capability of expeditionary warfighters by increasing the efficiency and effectiveness of energy production, storage, distribution and use. Beyond traditional energy efforts, this portfolio also looks at other issues, including energy-efficient behaviors and hybridization of energy sources. These pillars are thoroughly integrated and perpetually related in execution. ***FY 2019 Plans:*** This activity has development and demonstration of advanced technologies to anticipate and reduce maintenance demands while increasing reliability. This includes advanced technology demonstrations of advanced manufacturing methods including metal Additive Manufacturing, friction stir welding and additive friction stir welding, and cold spray for structural repair of Marine Corps equipment, creation of near net shaped parts, and advanced part demonstrations. This also includes research into the digital thread of information and cyber security required, from cradle to grave, for digital manufacturing methods, from raw materials through design, production, and qualification of parts for Marine Corps applications. This research area also includes advanced technology demonstrations that predict vehicle health and prognostics of remaining useful life for military ground vehicles and equipment in support of Condition Based Maintenance (CBM) goals, while seeking to automate CBM practices through automatic data retrieval and algorithm development.					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
The activity also will demonstrate the military utility of enhancing combat capability by increasing energy production, storage, distribution, and curbing energy consumption of the individual Marine and other tactical assets. This includes advanced system research into the scaled use of high specific power solar cell for Marine Corps applications ranging from the individual warfighter to augmenting the power and combat endurance unmanned robotic vehicles. Additionally investigated, system level research and demonstration of enhanced power and energy technologies to support the Marine warfighter as a system, to include enhanced power and energy storage technology, more energy efficient equipment, and enhanced power networks that enhance mission duration, decrease combat load, and enhance combat performance. ***FY 2020 Base Plans:*** Logistics development will focus on the broad range of technologies to demonstrate the military utility of enhancing combat capability by increasing energy production, storage, distribution, and curbing energy consumption of the individual Marine and other tactical assets. This includes advanced system research into the scaled use of high specific power solar cell for Marine Corps applications ranging from the individual warfighter to augmenting the power and combat endurance unmanned robotic vehicles. Additionally investigate, system level research and demonstration of enhanced power and energy technologies to support the Marine warfighter as a system, to include enhanced power and energy storage technology, more energy efficient equipment, and enhanced power networks that enhance mission duration, decrease combat load, and enhance combat performance. Research into friction stir welding and additive friction stir welding, and cold spray for structural repair of Marine Corps equipment will be completed. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The decrease from FY 2019 to FY 2020 is associated with completion of research into friction stir welding, additive friction stir welding, and cold spray for structural repair of Marine Corps equipment.					
Title: MANEUVER ***Description:*** This activity investigates new ways and means to land forces and material through contested sea-land surface interfaces and then conduct maneuver warfare. In order to enable future Amphibious Operations, research efforts will support autonomous operations across the sea-surf-ground environment, improved fuel efficiency and speed of amphibious vehicles, amphibious vehicle technologies, water performance, and amphibious payloads to change the dynamics of a surface amphibious assault. This includes the emergence manned-unmanned teaming and autonomous vehicle collaboration.	13.896	13.270	14.526	0.000	14.526

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
The technologies included in this work address areas of mobility, materials, propulsion, signature reduction, modularity, and unmanned systems. ***FY 2019 Plans:*** FY 2019 Plans include development and evaluation of mobility technologies and future concepts for the ground and amphibious fleet to improve maneuverability across a range of challenging terrain environments. Work will emphasize experimentation with autonomy approaches through both simulation and live events for amphibious vehicles from small low cost craft, traditional amphibious combat and assault vehicles, and landing craft. Additional focus will be on integrating real time precepts with learned information, a priori knowledge, and contextual understanding to facilitate informed autonomous decision making. There will be demonstration and experimentation with systems that enable intelligent planning, reasoning, learning, and control to affect tactically appropriate autonomous behaviors in littoral and urban environments. In addition efforts will be pursued in component technology and prototypes for future advanced manned expeditionary ground vehicles and amphibians. ***FY 2020 Base Plans:*** FY 2020 Plans include research and evaluation of advanced technologies for full combat systems. Demonstrator platforms will be developed that integrate novel propulsion, mobility, and autonomous technologies to enable enhanced land operations and seamless transition between land and water environments. The automation and autonomy systems developed will concentrate on the surf-zone and beach operations and include work to include development of unmanned swarming amphibious assault craft. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase from FY 2019 to FY 2020 is associated with development of new maneuver technologies to enhance the mobility, agility, signature, and warfighting capabilities of advanced combat vehicles, including unmanned swarming amphibious assault craft.					
Title: EXPEDITIONARY CYBER ***Description:*** This activity provides freedom of maneuver and influence in the cyber-electronic warfare domain while simultaneously denying the same to the adversary and protecting critical command systems. Technologies are being developed using a multi-disciplinary approach that combines Radio Frequency electronics, digital	4.180	2.475	0.000	0.000	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
signal processing, computer engineering, software engineering, machine learning and data science to support Naval Expeditionary warfighters operating with size, weight and power constrained equipment in Disrupted, Intermittent, Limited environments. Areas of applied research include distributed precision time, predictive software defined radio architectures, coordinated Cyber and Spectrum maneuver to mitigate detection and exploitation, tactical Cyber visualization, discovering and mapping networks in dense urban environments, contextual awareness and blind channel characterization. ***FY 2019 Plans:*** The Expeditionary Cyber portfolio focuses heavily on the development and integration of multiple underlying technologies into subsystems and system demonstrations supporting experimentation. The Expeditionary Cyber portfolio is also closely coordinated with the Command, Control, Communications and Computers research portfolio also described herein to efficiently exploit co-design opportunities and shorten development times needed to keep pace in an environment rapidly driven by Moore's Law. Battle damage assessment technologies are integrated into system sensor technologies to prove efficacy in an increased Technology Readiness Levels application in cyber experimentation. Cyber experimentation will be performed on an autonomous system operating in a test range. Novel resilient cyber components and architectures integrated into a multi-function cyber Electronic Warfare system will be demonstrated in a realistic Electro-Magnetic environment measuring performance. ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The plans and associated programs contained in this activity and Project 2958 are realigned from the Marine Corps ATD Project 2223 in PE 0603640M Marine Corps Advanced Technology Demonstrations beginning in FY 2020. The FY 2020 increase will initiate a concerted research effort to develop a rapid testing tool of major C2 and weapon systems addressed in NDAA 1647. Adversaries are finding vulnerabilities in our systems faster than our acquisition cycle can patch them. This effort is to provide acquisition sponsors and operational planners a method to identify and project vulnerabilities and impacts within computing systems and networks as well as an					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
operational assessment measure to determine how to proactively address these issues and maximize projection power.					
Accomplishments/Planned Programs Subtotals	94.567	100.979	95.327	0.000	95.327

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

The primary objective of this PE is the development of technologies to meet unique Marine Corps needs in conducting Expeditionary Maneuver Warfare. The program consists of a collection of projects categorized by critical warfighting function. Individual project metrics reflect the technical goals of each specific project. Typical metrics include the advancement of related Technology Readiness Levels, the degree to which project investments are leveraged with other performers, reduction in life cycle cost upon application of the technology, and the identification of opportunities to transition technology to higher categories of development.

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COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
2297: *Futures Directorate*	0.000	58.354	46.830	73.046	-	73.046	65.781	67.116	68.427	69.796	Continuing	Continuing

A. Mission Description and Budget Item Justification

As a subordinate organization under the Deputy Commandant, Combat Development and Integration (DC, CD&I), the mission of the Marine Corps Warfighting Laboratory / Futures Directorate (MCWL/FD) is to identify future challenges and opportunities, develop warfighting concepts, and comprehensively explore options in order to inform the combat development process to meet the challenges of the future operating environment. DC, CD&I is designated as the United States Marine Corps (USMC) Advocate for Science and Technology (S&T). MCWL's Commanding General (CG) is the DC, CD&I designated Proponent of USMC S&T and serves as the USMC Executive Agent for Marine Corps S&T. The MCWL/FD also serves as the Marine Corps' liaison to the Joint Staff for Joint Concept Development and Experimentation; thereby facilitating service-specific experiments as well as participation in joint service experimentation.

The current MCWL/FD Campaign Plan addresses how the Naval Services must reshape their capabilities in order to meet the concepts and Concepts of Operations (CONOPS) called for in the Secretary of the Navy's "Cooperative Strategy 21" and the Marine Corps' capstone Marine Operating Concept (MOC), according to the objectives of the Commandant of the Marine Corps' guidance to develop the future Marine Corps Force 2025. Execution of the MCWL/FD Campaign Plan results in recommendations to Marine Corps advocates and proponents so that they may more cohesively and logically structure the future Navy and Marine Corps team. In support of the Marine Corps' role to provide an ever-ready quick strike force to protect US interests, MCWL/FD pursues concepts and new capabilities focused on the Marine Air-Ground Task Force (MAGTF). The MAGTF is the Marine Corps' doctrinal, task organized, force deployment package. It consists of four elements: the Command Element that provides overarching Command and Control of the entire force; the Ground Combat Element normally built around a core infantry unit with supporting armor, artillery, and other ground units; the Aviation Combat Element which provides aircraft, air defense, and other aviation functions; and the Logistics Combat Element which consists of Combat Service Support elements including medical, supply, and transportation. Marine Corps Force 2025 also seeks to maximize the employment of electronic, information, and cyber warfare, as well as manned/unmanned teaming, within each element of the MAGTF. MCWL/FD also examines future enhancements in training, organization, and equipment. MCWL/FD accomplishes its mission through five subordinate Divisions:

Futures Assessment Division's mission is to: research, examine, and describe plausible future security environments 15 to 30 years into the future. Knowledge of these future security environments will provide an estimate of possible future threats, challenges, and opportunities, to include: the rise of possible partners and adversaries, emerging disruptive technologies, and likely sources of conflict. This work is largely accomplished through research, seminar participation, and coordination with various experts in academia, the intelligence community, and think tanks.

The mission of Concepts and Plans Division is to: examine select future security environments, emerging warfighting opportunities and challenges, and Naval warfare and joint/coalition integration and capabilities, in order to develop Marine Corps Service concepts and CONOPS to promote development of the emergent Marine Corps force. CAP is responsible for the production of formally published concepts, CONOPS, and options for future force organization and posture that describe how the Marine Corps will operate and fight.

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Wargaming Division conducts formal wargames to frame emerging warfighting concepts, establish the Joint context for the Marine Corps Force Development System, and identify opportunities for development of experimental and non-experimental capabilities.

Experiment Division conducts live force concept-based experimentation to facilitate exploration of prototype and surrogate technologies, as well as Tactics, Techniques, and Procedures (TTPs), in order to better refine equipment requirements and to identify Doctrine, Organization, Training, Materiel, Leadership, Personnel, and Facilities (DOTMLPF) initiatives needed to produce future capabilities.

Science and Technology (S&T) Division conducts investigations and assessments to identify, modify where appropriate, and evaluate technological capabilities that support advanced warfighting concepts, and to explore the military utility of promising new commercial or government technologies in support of urgent and compelling needs. MCWL/FD investigates the relevance to MOC-prescribed capabilities and gaps of advanced technologies according to the following Thrust Areas: Command, Control, Communications, and Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR); Autonomy and Robotics; MAGTF Fires; Maneuver; Expeditionary Logistics (to include Expeditionary Energy); Expeditionary Medicine; Cyber and Electronic Warfare (EW); and Force Protection.

This project is organized into 6 activities, the core of which are represented by the Warfighting Capability Areas of the MAGTF. The project emphasizes development and demonstration of advanced technology capability concepts, and the examination of their operational application and military utility in the context of live-force field experimentation with Marines. This operational experimentation directly supports Marine Corps combat development to inform future capability requirements and optimize the acquisition process.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: COMBAT SERVICE SUPPORT (CSS) AND FORCE PROTECTION	18.206	8.142	9.447	0.000	9.447
Description: This activity includes Marine Corps Warfighting Laboratory / Futures Directorate (MCWL/FD) Combat Service Support and force protection experimentation efforts including assessment of equipment, new Tactics, Techniques, and Procedures, training programs, and proposed organizational changes associated with enhanced capabilities. This area provides seabasing, expeditionary logistics, urban combat, and expeditionary medicine experimentation support. Although this category covers a few small (less than $500K per FY) efforts being pursued by MCWL/FD, most programs listed below are considered major (valued at $500K or more) or have near real-time operational impact. Investments in this activity may be conducted under the Thrust Areas of Expeditionary Logistics, Expeditionary Medicine, Force Protection, or Autonomy and Robotics. ***FY 2019 Plans:*** Continue to develop prototypes and experiment with logistics enablers in support of dismounted operations and the Expeditionary Force-21 concept. This includes completing assessment and experimentation to understand the relevance of autonomy to ship to shore surface connectors to focus on development and experimentation with afloat and forward-deployed metal adaptive manufacturing. Continue to explore technologies and					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
methodologies that reduce resource consumption and enhance sustainability of the distributed units. Pursue investigations and experimentation with independent, conditioned, reliable power sources to dismounted and/or distributed forces operating in austere conditions. Wrap-up assessments and experimentation in order to provide logistics common operational picture for commanders and logistics planners across the area of operations. Continue to develop and study technologies that enhance unit survivability; to include various aspects of critical care and medical related protocols and processes.					
FY 2020 Base Plans: Develop prototypes and experiment with logistics enablers and air defense enhancements in support of Expeditionary Advanced Base Operations (EABO) and Littoral Operations in a Contested Environment (LOCE) as prescribed by the Marine Operating Concept (MOC). This includes development and experimentation with autonomous sea-based surface connectors for over-the-horizon missions during ship-to-shore maneuvers. Experiment with efficient and redundant hybrid energy platforms providing reliable electrical power using multiple fuel input sources. Develop a highly mobile and efficient hybrid power generation and storage capability that provides the flexibility to operate with a variety of energy sources in support of EABO. Effort includes developing a modular design combining JP-8 fuel cell, solar, battery and energy scavenging technologies. Integrate hybrid/electric capabilities within the MAGTF to experiment with alternative vehicle power, extended mobility, and logistics demand reduction functions; building Concepts of Operations (CONOPS) and TTPs for tactical mobility utilizing electric/hybrid power as a fuel source. Improve ground maneuver force and critical installation defense against small unmanned aerial systems (UASs). Effort includes development of new counter UAS architectures, integration of new sensors for detection and tracking, and development of new counter-UAS defeat mechanisms. Develop, test, and evaluate autonomous/automated aerial platforms for logistics resupply. Develop and experiment with highly autonomous and synchronous logistics capabilities in support of expeditionary MAGTF operations, offering increased flexibility and speed to Marines by means of seamless, end to-end logistics chain management and execution. Effort includes air, sea, and ground based systems, providing tactical commanders with an organic, responsive, and flexible option(s) to support disbursed and semi-independent maneuver operations. Develop an autonomous explosive detection and defeat capability. Continue to develop and experiment with medical technologies that enhance survivability; includes power management and energy scavenging capabilities which will enable more effective casualty warming and blood storage/distribution. Integrate and experiment with systems to provide battlefield medical command and control and information management.					
FY 2020 OCO Plans:					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increase from FY19 to FY20 is directly attributable to the development and enhancement of capabilities to provide a hybrid logistics design to a more distributed technologically advanced force and increase range and effectiveness of the Marine Corps Air-Ground Task Force (MAGTF) against airborne threats. Funding supports the Commandant of the Marine Corps' (CMC's) priorities of Logistics Transformation and Air Defense.					
Title: MARINE AIR-GROUND TASK FORCE (MAGTF) COMMAND, CONTROL, COMMUNICATIONS, AND COMPUTERS (C4) ***Description:*** This activity encompasses all Marine Corps Warfighting Laboratory/Futures Directorate (MCWL/FD) Command, Control, Communications, and Computers (C4) experimentation efforts including assessment of equipment, new Tactics, Techniques, and Procedures (TTPs), training programs, and proposed organizational changes associated with enhanced C4 capabilities. The area provides cutting edge/enhanced Over-The-Horizon (OTH), Beyond Line of Sight (BLOS), satellite and non-satellite based C4 capabilities to support experimentation. Although this category covers a few small (less than $500K per FY) efforts being pursued by MCWL/FD, most programs listed below are considered major (valued at $500K or more) or have near real-time operational impact. Investments in this activity will be conducted under the Thrust Areas of Command, Control, Communications, and Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) and Cyber/Electronic Warfare (Cyber/EW). ***FY 2019 Plans:*** Continue to identify and assess a collaborative solution that provides tailorable Over-the-Horizon (OTH), On-the-Move (OTM) communications, situational awareness, and fires for the forward deployed Marine Air-Ground Task Force (MAGTF) to include Digital Integration (DI). Experiment with a BLOS, OTH, OTM voice, data, and position location information network in an Expeditionary Force 21 (EF-21) environment. Continue to research an organic and persistent capability to receive, process, and disseminate digital information wirelessly to dismounted users and dismounted operations (operations conducted on foot). Conclude development and assessment of systems that permit Unmanned Aerial System (UAS) operations in a Global Positioning System (GPS) denied environment. ***FY 2020 Base Plans:*** Conduct research to identify and assess a collaborative solution that provides tailorable Over-the-Horizon (OTH), On-the-Move (OTM), and Beyond Line of Sight (BLOS) communications, situational awareness, and	10.525	8.614	9.269	0.000	9.269

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
fires for units across a wide spectrum of air, ground, and sea operations. Experiment with an organic and persistent capability to wirelessly receive, process, and disseminate digital information from organic sensors (to dismounted users), with relevant and/or immediately actionable information. This is done while simultaneously enabling BLOS digital connectivity to both higher and adjacent units (supporting dismounted operations). Effort will enable BLOS digital connectivity to higher and adjacent units. Initiate efforts to automate the identification of targets and expedite the sharing of information between sensors, shooters, and approval authority. Integrate electronic warfare technologies (ground and airborne sensors) and cyber space warfare technologies into demonstrations and live-force experiments to inform requirements and develop Tactics, Techniques, and Procedures (TTPs) for use by operational forces. Experiment with a cyber mission execution framework enabling military commanders, planners, and operators to collaborate, understand, plan, and manage cyber operations in real-time against large-scale and dynamic network environments. Initiate cyber and communications infrastructure common operational picture tactics and procedures for situational awareness and coordination of battlefield effects. Experiment with worldwide social media mapping. This technology will enable real-time situational awareness of the information environment (IO), including content and location of social media users. Open IO technology will provide Marines at the tactical edge with alerts using civilian and adversary open source communications. Provide units at the tactical edge IO situational awareness, planning, and command and control tools to include measures of effectiveness. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increase from FY19 to FY20 is directly attributable to the development and enhancement of capabilities to communicate, shoot, and move in a degraded environment; increasing situational awareness and influencing decision making. Funding supports the Commandant of the Marine Corps' (CMC's) priorities of Command and Control and Information Warfare.					
Title: FIRES, TARGETING, AND MANEUVER	6.114	6.029	7.174	0.000	7.174
Description: This activity includes Marine Corps Warfighting Laboratory / Futures Directorate (MCWL/FD) experimentation efforts in the areas of fires, targeting, and maneuver including assessment of equipment, new Tactics, Techniques, and Procedures (TTPs), training programs, and proposed organizational changes associated with enhanced capabilities. This area increases fires, targeting, and maneuver related troop environmental awareness, lethality, and mobility using fused sensors as well as unmanned weaponized and reconnaissance air and ground vehicle platforms to support experimentation. Although this category covers					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
a few small (less than $500K per FY) efforts being pursued by MCWL/FD, most programs listed below are considered major (valued at $500K or more) or have near real-time operational impact. Investments in this activity will be conducted under the Thrust Areas of Marine Air-Ground Task Force (MAGTF) Fires, Maneuver, and Autonomy and Robotics. ***FY 2019 Plans:*** Continue to develop technologies, demonstrate, and experiment with robotic systems organic to an infantry company for intelligence collection, indirect fires, direct fires and breaching capabilities. Complete assessment of the expeditionary utility of autonomous swarming technologies for unmanned air and ground systems. Pursue company level precision guided munitions. Initiate efforts to provide a missile system with a real-time wireless data link to provide lethal beyond line of sight fires (sea-land and land-land) against static and moving targets in the urban littoral environment. Automate robotic control systems/software to reduce the burden of control and increase manned and unmanned teaming. Initiate and complete investigations into battery configuration and ruggedization as well as associated battery-driven gearbox of an amphibious electric all-terrain vehicle. ***FY 2020 Base Plans:*** Continue to provide a multi-purposed Unmanned Ground Vehicle (UGV) which hosts a government-owned modular payload architecture and provides the ability to rapidly modify payloads for a variety of missions across the MAGTF. In concert, evaluate various payloads that enhance dismounted unit abilities across the warfighting functions. Continue to pursue company level precision guided munitions to increase responsiveness, survivability, and lethality to the ground combat element. Specifics include development of: a multi-tubed launcher integrated with a UGV and the ability to remotely launch Unmanned Aerial Systems (UASs) from distributed positions. Experiment with a multi-purpose, electro-optical missile system with a real-time wireless data link for ranges up to 25km; operated in either direct attack or mid-course navigation based on target coordinates. The system has the ability to carry a heat, fragmentation, or anti-armor payload and can be integrated with a variety of sea, air, and land platforms. Initiate pursuit into a recoverable, long-range reconnaissance and precision strike asset with lethal capability against armored targets. Facilitate the integration of a small UAS with the identification, engagement, assessment, and adjustment of indirect fires for an individual Marine operating with an indirect fire weapon. Increase lethality of ground forces through rapid design iteration and testing of small UASs (sUASs), including advanced sensors and warheads. Experimentation efforts will include integration of critical payloads for immediate use and will enable earlier force training. Assess potential solutions to identified marksmanship capability gaps. Ensure the availability of Utility Task Vehicles (UTVs) for integration, testing, assessment throughout the experimentation cycle. Pursue technologies to dramatically					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
increase the range and lethality of the MAGTF using a Low-Cost Unmanned Aerial Vehicle (UAV) with integrated swarming technology to create a Lethal Miniature Aerial Munition (LMAM). Experiment with loitering munitions launched from a variety of platforms (air, ground, and sea). Conduct swarming follow-on efforts to develop distributed, cognitive, collaborative, and cooperative swarming behaviors for maximum effect and complexity on target. Investigate Naval Surface Missile (NSM) simulators for experimentation of weapons system and integration with naval system queuing. NSM simulator systems will be used to exercise the NSM coastal defense system in coordination with Naval target sensing and tasking, allowing Naval vessels to queue and task NSM launch. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increase from FY19 to FY20 is directly attributable to the development and enhancement of capabilities to increase range and precision of indirect fires and enhance maneuver at sea with sustained mobility ashore. Funding supports the Commandant of the Marine Corps' (CMC's) priorities of long range precision fires and protected mobility.					
Title: MARINE AIR-GROUND TASK FORCE (MAGTF) INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE (ISR) ***Description:*** This activity includes Marine Corps Warfighting Laboratory / Futures Directorate (MCWL/FD) Intelligence, Surveillance and Reconnaissance (ISR) related experimentation efforts including assessment of equipment, new tactics, techniques, and procedures (TTPs), training programs, and proposed organizational changes associated with enhanced ISR capabilities. Using a variety of fused sensors to mesh data, video, and images and incorporating a common tactical controller to operate multiple air and ground ISR platforms, this area enhances small unit situational awareness as well as exploitation and forward engagement ability via experimentation. Although this category covers several small (less than $500K per FY) efforts being pursued by MCWL/FD, most programs listed below are considered major (valued at $500K or more) or have near real-time operational impact. Investments in this activity will be conducted under the Thrust Areas of Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) and Autonomy and Robotics. ***FY 2019 Plans:***	6.414	4.376	20.869	0.000	20.869

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Continue to increase situational awareness of battlespace in order to defend against and repel enemy attacks in those domains at the company and lower echelons. Assess systems to combine sensor and telemetry data from multiple unmanned platforms (ground, surface (water), and air) in order to provide a more relevant and usable tactical picture. Initiate efforts to provide a small, lightweight, semi-autonomous system that can self-navigate structure interiors while simultaneously visibly inspecting and creating real-time three-dimensional (3D) maps. ***FY 2020 Base Plans:*** Expand development of government-owned Unmanned Aerial Systems (UAS) architecture to allow for rapid design iterations in support of experimentation. Effort will continue to provide situational awareness of the battlespace, incorporating payloads that improve navigation and allow for multi-mode sensors. Experiment with enabling technologies to combine sensor and telemetry data from multiple unmanned platforms (ground, surface (water), and air); minimizing operator intervention over current systems, with the ability to react in a wide range of operational tasks, environmental conditions, and landscapes. Continue to develop a capability to display and control a myriad of unmanned platforms and sensor inputs in a fused network on a common controller for Intelligence, Surveillance and Reconnaissance (ISR) as well as target identification and prosecution. Initiate experimentation with an autonomous reconnaissance system, improving threat situational awareness and reducing tactical surprise to assault forces on long range missions. Initiate an effort to receive, transmit, and fuse joint asset specialized sensor information to communications nodes afloat and ashore via an aerial gateway. Expand investigations to add a Mission-Configurable Software Defined Radio with an Electronically Steerable Array (ESA) to the currently developed communication pod. Missions will include, but not be limited to, Early Warning radar, Cueing radar and/or Electro-magnetic Spectrum Operations. Effort will utilize Artificial Intelligence (AI) software to fuse sensor information in order to generate track information on-board the pod and then push it to both terrestrial communications nodes and directly to aircraft. Seek to provide a multi-role, long reach, expeditionary, next generation network of ISR capabilities. This includes the enhancement of capabilities for multi-sensor collection, fusion and real-time transmission; multi-electro-magnetic spectrum operations; C4 network bridge and relay; escort and protection for assault forces; persistent and precision fires and targeting; integration of an early warning air defense network; and informing assault support. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY19 to FY20 funding increase is directly attributable to the development and enhancement of capabilities to increase situational awareness and influence decision making. Funding supports the Commandant of the					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Marine Corps' (CMC's) priority of Command and Control. Notably, this increase includes $15M to pursue Phase II of efforts initiated to receive, transmit, and fuse joint asset specialized sensor information to communications nodes afloat and ashore via an aerial gateway.					
Title: MARINE CORPS WARFIGHTING LABORATORY / FUTURES DIRECTORATE (MCWL/FD) OPERATIONS (SUPPORT) ***Description:*** Marine Corps Warfighting Laboratory / Futures Directorate (MCWL/FD) Operations (Support) efforts include overall MCWL/FD experimentation doctrine, planning, analysis, data collection, as well as technology transition tracking efforts. This area provides overarching experimentation doctrine, planning, management, technical/engineering support, analysis, data collection, and reporting. Programs listed below are considered major (valued at $500K or more) or have near real-time operational impact. ***FY 2019 Plans:*** Continue to provide encompassing experimentation doctrine, planning, analysis, and data collection in order to conduct relevant enactments and report on experimentation results. Look to the future and identify up and coming (cutting edge) technology areas of interest. Provide generalized as well as specific program engineering, technical, and management support. ***FY 2020 Base Plans:*** MCWL/FD will elicit a broad range of unique analytical expertise to evaluate experiments in various warfighting areas. Design experimentation plans, collect data during experiments, perform reconstruction and analysis of experiments, and prepare experiment analysis reports. Identify global commercial technology trends/innovations and disruptive technologies which may impact future Marine Corps capabilities. Expand upon generalized as well as specific program level engineering, technical, and management support. In addition, technical program area management capability increased. Initiate investigations into development of a narrow Artificial Intelligence (AI) capability which is capable of automating data collection to assist in tracking and decision making regarding technology based programs of interest. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:***	11.029	12.420	13.087	0.000	13.087

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
The increase from FY19 to FY20 is due to initiating an automated data collection effort to assist in tracking technology-based programs of interest in support of portfolio decision-making.					
Title: WARFIGHTING EXCELLENCE	6.066	7.249	13.200	0.000	13.200
Description: This activity includes Marine Corps Warfighting Laboratory / Futures Directorate (MCWL/FD) efforts in the development and assessment of joint and service warfighting concepts, joint and service missions, analysis of emerging threats and opportunities, and joint capability experimentation. It also includes MCWL/FD service experimentation in areas that impact multiple warfighting functions. Although this category covers several small (less than $500K per FY) efforts being pursued by MCWL/FD, most programs listed below are considered major (valued at $500K or more) or have near-real-time operational impact. ***FY 2019 Plans:*** Continue to support the combat development process by helping to develop and refine emerging concepts, conceptualize force design, and identify future capabilities and deficiencies within future operating environments. This is accomplished by means of enhancing current functional capabilities by investigations into Next Generation Wargaming tools as well as conducting extensive wargaming as an augmentation to live force experimentation. Efforts include 11 planned wargames (4 large, 5 medium, and 2 small) with areas of interest covering Expeditionary Force-21 (EF21) related concepts. Focusing 15 to 30 years in the future, continue to offer top level identification and analysis of emerging asymmetric threats and opportunities. This is accomplished by capitalizing on a myriad of foresight assessments of future operating environments. Continue to develop, assess, and provide insight into joint efforts and warfighting concepts. Specific areas of investment include: 1) Demonstrating the military utility of a resilient, low-cost, effective, high-altitude balloon-borne communications platform that can be rapidly deployed to enhance warfighter communication capabilities and 2) Informing the development of distributed mobile amphibious (and ground) assault fuel logistics capabilities as well as demonstrating the feasibility of executing the concept in support of a "fight tonight" scenario using current fleet assets, by adapting current naval practices. Initiate investigations into candidate technologies that support urban operations, in an effort to identify/eliminate capability gaps and develop TTPs to include subterranean maneuver. This is an attempt to: 1) Develop a 5th generation force capable of ship to shore movement against a peer adversary, enabling distributed maneuver at varied distances and 2) Develop a 6th generation force capable of dominating the urban environment. The concepts: 1) Explore innovative delivery systems to augment current ability to maneuver troops, effects, and materiel from ship to shore in contested environments and 2)					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Involve integration by engineers and scientists with planners and operators to identify key capability concept areas for development.					
FY 2020 Base Plans: Aid the combat development process by conducting 11 core wargames. Focus areas include Marine Operating Concept (MOC) supported Expeditionary Advanced Base Operations (EABO) and Littoral Operations in a Contested Environment (LOCE). Create an effective collaborative wargaming environment that will increase the use of automated and analytical tools, and will provide the necessary quantitative and qualitative output for Marine Corps capability/concept development. Coordinate with the Marine Corps Systems Command's (MCSC's) Wargaming Center of Excellence to provide an encompassing wargaming ability throughout the Marine Corps. Focusing 15 to 30 years in the future, continue to offer top level identification and analysis of emerging asymmetric threats and opportunities. This is accomplished by capitalizing on a myriad of foresight assessments of future operating environments. Maintain insight and continue making contributions to support approved Joint Concept Technology Demonstrations (JCTDs) and Emerging Capability Technology Demonstrations (ECTDs) efforts and warfighting concepts; intended to provide rapidly fieldable capabilities by using emergent mature technologies matched with innovative operational concepts. This includes furthering demonstrations with a high-altitude balloon-borne communications platform and continuing development efforts of distributed mobile amphibious (and ground) assault fuel logistics capabilities. The communications platform effort involves demonstrating and experimenting with the military utility of a resilient, low cost, effective, high-altitude balloon-borne communications platform that can be rapidly deployed to enhance warfighter communications capabilities. The fuel logistics efforts include demonstration and experimentation to build the concept of employment as well as tactics, techniques, and procedures (TTPs) for inflatable, scalable, double-walled fuel storage, transport, and transfer systems for bulk fuel logistics. Continue in the conduct of a multi-year effort to enhance situational awareness; Command and Control (C2); and fires and maneuver in the dense urban environment. Conduct experimentation events to identify changes in training, organizing, and equipping future forces and provide venues for live-force evaluation and assessment. Bring concept developers, operational Subject Matter Experts (SMEs), and technologists together in order to discover, purchase, and assess new and advanced technologies that can aid in the implementation and refinement of the Expeditionary Advanced Base (EAB) concept. Additionally, by exposing technology and acquisition professionals to the concept, future development can be guided. Explore the use of modeling and simulation tools and techniques to gather, process, analysis, and utilize operational data in support of experiment development, execution, and assessment. Capitalizing on an OSD 2 year investment, provide organic, experimental opposition force capability (Red Team, Red Cell and Live Adversary Force). This will assist in providing a more realistic,					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
adaptive, and cohesive enemy force/civil infrastructure for wargames, command post exercises, simulations, and experimentation events in order to support free-play, friendly force adaptation and decision-making skills. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY19 to FY20 increase is due to expanded investments into: coordinated efforts to enhance wargaming capabilities, participation in joint rapidly fieldable efforts, and testing/experimentation with new technologies identified to enhance the Expeditionary Advanced Base Operation (EAB) concept. In addition, the increase in funding is due to the initiation of providing an organic, experimental opposition force capability to augment live-force experimentation.					
Accomplishments/Planned Programs Subtotals	58.354	46.830	73.046	0.000	73.046

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

The primary objective of this Project is the development, demonstration, and assessment of technologies that represent capabilities to meet unique Marine Corps needs in conducting Expeditionary Maneuver Warfare in the future. The program consists of a collection of projects categorized by critical warfighting function. Individual project metrics reflect the technical goals of each specific project. Typical metrics include the advancement of related Technology Readiness Levels, the degree to which project investments are leveraged with other performers, reduction in life cycle cost upon application of the technology, and the identification of opportunities to transition technology to higher categories of development.

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COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
2958: *Cyberspace Activities*	0.000	0.000	0.000	4.474	-	4.474	4.476	4.477	4.566	4.657	Continuing	Continuing

Note

The plans and associated programs contained in this Project are realigned from the Expeditionary CYBER Project 2223 in PE 0603640M MC ADVANCED TECHNOLOGY DEMO beginning in FY 2020.

A. Mission Description and Budget Item Justification

This Project activity provides freedom of maneuver and influence in the cyber-electronic warfare domain while simultaneously denying the same to the adversary and protecting critical command systems. Technologies are being developed using a multi-disciplinary approach that combines Radio Frequency electronics, digital signal processing, computer engineering, software engineering, machine learning and data science to support Naval Expeditionary warfighters operating with size, weight and power constrained equipment in Disrupted, Intermittent, Limited environments. Areas of applied research include distributed precision time, predictive software defined radio architectures, coordinated Cyber and Spectrum maneuver to mitigate detection and exploitation, tactical Cyber visualization, discovering and mapping networks in dense urban environments, contextual awareness and blind channel characterization.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**
Title: Expeditionary Cyber	0.000	0.000	4.474	0.000	4.474
FY 2019 Plans: N/A					
FY 2020 Base Plans: Cyber related demonstrations and experimentations will be conducted to verify the secure transfer of information across mobile tactical user platforms. Controlled demonstrations will be conducted to assess battle damage on a class of systems from the use of cyber effects. Demonstrations of cyber hardened operational systems will be conducted to showcase improved resiliency. Software redesign of modular Cyber/Electronic Warfare systems will be demonstrated as a proof of concept prototype. Initiate research to develop a rapid testing tool of major C2 and weapon systems to provide acquisition sponsors and operational planners a method to identify and project vulnerabilities and impacts within computing systems and networks as well as an operational assessment measures to determine how to proactively address these issues and maximize projection power.					
FY 2020 OCO Plans: N/A					
FY 2019 to FY 2020 Increase/Decrease Statement:					

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Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603640M / *MC Advanced Technology Demo*	**Project (Number/Name)** 2958 / *Cyberspace Activities*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
The FY20 increase will initiate a concerted research effort to develop a rapid testing tool of major C2 and weapon systems addressed in NDAA 1647. Adversaries are finding vulnerabilities in our systems faster than our acquisition cycle can patch them. This effort is to provide acquisition sponsors and operational planners a method to identify and project vulnerabilities and impacts within computing systems and networks as well as an operational assessment measures to determine how to proactively address these issues and maximize projection power. The plans and associated programs contained in this activity and Project 2958 are realigned from the Marine Corps ATD Project 2223 in PE 0603640M Marine Corps Advanced Technology Demonstrations beginning in FY 2020.					
Accomplishments/Planned Programs Subtotals	0.000	0.000	4.474	0.000	4.474

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

The primary objective of this Project is the development, demonstration, and assessment of technologies that represent capabilities to meet unique Marine Corps needs in conducting Expeditionary Cyber Warfare in the future. The program consists of a collection of projects categorized by critical warfighting function. Individual project metrics reflect the technical goals of each specific project. Typical metrics include the advancement of related Technology Readiness Levels, the degree to which project investments are leveraged with other performers, reduction in life cycle cost upon application of the technology, and the identification of opportunities to transition technology to higher categories of development.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603640M / *MC Advanced Technology Demo*	Project (Number/Name) 9999 / *Congressional Adds*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	12.071	27.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	39.071

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Program Increase	12.071	0.000
FY 2018 Accomplishments: Research conducted under this Project includes advanced technology programs sponsored and managed from both the Office of Naval Research (ONR) and the Marine Corps Warfighting Laboratory/Futures Directorate (MCWL/FD). ONR is funding the development and demonstration of a variant of the 81mm Advanced Capability Extended Range Mortar (ACERM) with improved size, weight, power and cost (SWAP-C) through the insertion of an optimized actuator. The ACERM technology enhances the mission effectiveness of USMC infantry forces through a significant increase in maximum range, while providing a first round on target capability against both stationary and moving targets while minimizing the relative increase in unit cost. In addition, the development of a Cannon Delivered Area Effects Munition (CDAEM) payload will be developed for the 155mm Moving Target Artillery Round (MTAR). The capability will greatly enhance the USMC's ability to effectively engage area targets to destroy, neutralize, and/or suppress threat platforms and facilities, and deny threat forces full operational freedom within the targeted area when there is a lack of precise target location, as is often the case with moving forces, counter fire missions, or when threat forces employ battlefield obscurants. MCWL/FD is sponsoring experiments to determine the military utility of small tactical autonomous unmanned ground vehicle systems to support logistics, fires and maneuver. Funds support the development and demonstration of tactical ground robotic vehicle systems as well as autonomy and perception algorithms utilizing a common ground control system. The capability will greatly enhance the tactical effectiveness, survivability, and lethality of tactical infantry formations in close combat operating environments. ***FY 2019 Plans:*** N/A		
Congressional Add: Common Unmanned Aerial Vehicle Simulation System	0.000	10.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603640M / *MC Advanced Technology Demo*	**Project (Number/Name)** 9999 / *Congressional Adds*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
FY 2018 Accomplishments: N/A ***FY 2019 Plans:*** Develop technology for mission simulation to help reduce the development cycle time of UAVs.		
Congressional Add: Flight Motion Simulator and Testing of UAVs ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Conduct research using computer simulation sensor modeling and actuator modeling in real-time with UAV hardware and software.	0.000	6.000
Congressional Add: Modular Advanced Armed Robotic System 2.0 ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** MCWL/FD continues to explore the military utility of small tactical autonomous unmanned ground vehicle systems to support logistics, fires and maneuver. FY19 funds include investment to develop fully autonomous operation, utilizing a common controller and Command and Control (C2) data links.	0.000	4.000
Congressional Add: UAS Air-Delivered Extended Range Munitions Demo ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Conduct research for technology maturation and testing of a full cartridge level solution prototype extended range guided projectile for an airborne platform. This proposed effort will develop and integrate enabling technologies with 81mm and 120mm extended mortar cartridges for launch from an airborne platform rather than ground launch from a mortar tube.	0.000	7.000
Congressional Adds Subtotals	12.071	27.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other Projects.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603651M *I JT Non-Lethal Wpns Tech Dev*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	13.090	13.313	13.307	-	13.307	13.301	13.564	13.840	14.116	Continuing	Continuing
3022: *Joint Non Lethal Weapons*	0.000	13.090	13.313	13.307	-	13.307	13.301	13.564	13.840	14.116	Continuing	Continuing

A. Mission Description and Budget Item Justification

The DoD Non-Lethal Weapons Program was established by the FY96 National Defense Authorization Act. The Office of the Secretary of Defense designated the Commandant of the
Marine Corps (CMC) as the DoD NLW Executive Agent (EA). The EA exercises centralized responsibility for joint research and development of non-lethal weapons and technology through the Joint Non-Lethal Weapons Program (JNLWP). The Office of the Under Secretary of Defense for Acquisition and Sustainment (A&S) serves as the OSD Principal Staff Assistant and oversees, in consultation with the Under Secretary of Defense for Policy, the DoD NLW Executive Agent.

The efforts described in this Program Element (PE) reflect science and technology (S&T) investment decisions by the Joint Non-Lethal Weapons (NLW) Integrated Product
Team, a multi-service flag level corporate board that provides executive oversight and management for the JNLWP for the CMC. This direction is based on the requirements and capabilities sought by the Services and the Coast Guard, as identified in the DoD's Non-Lethal Weapons Joint Capabilities Based Assessment Document. This coordinated joint S&T development approach addresses mutual capability gaps and assures the most relevant non-lethal technologies, capabilities and equipment are provided to the operating forces while eliminating duplicative service S&T investment. These advanced technology development initiatives feed non-lethal capabilities which directly support the National Defense Strategy (NDS) objective of strategic competition by providing options to the joint force in pursuit of national objectives in legal or policy constrained scenarios, as well as complementing the use of lethal effects in complex combat scenarios, for example, in urban environments with large civilian populations. Ongoing NLW studies, analyses and exercise efforts with NATO and Allies also support NDS objectives to strengthen alliances and partnerships. Resulting capabilities will facilitate a fully integrated non-lethal competency as a complement to lethal firepower, providing force application options for below lethal threshold engagements.

This program funds Advanced Technology Development of next-generation non-lethal capabilities and includes performing analysis, technology development efforts, and modeling and simulation necessary to ensure optimum weaponization and use of these capabilities. Investment areas include research and development of next-generation NLWs such as: non-lethal directed energy weapons (lasers, millimeter wave and high power microwave) for counter-personnel and counter-materiel missions; non-lethal counter-personnel technologies (acoustic, optical, and human electro-muscular disruption technologies), and advanced non-lethal materials (including materials for vehicle/vessel stopping and counter-facility applications). Next generation non-lethal systems focus on long-range localized non-lethal effects to identified threat individuals (or groups of individuals) and/or their threat weapons systems operating in complicated environments such as urban areas, crowds, buildings, vehicles, vessels, and also in close proximity to high-value civilian facilities.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy					Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*			R-1 Program Element (Number/Name) PE 0603651M *I JT Non-Lethal Wpns Tech Dev*		
B. Program Change Summary ($ in Millions)	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**
Previous President's Budget	13.448	13.313	13.307	-	13.307
Current President's Budget	13.090	13.313	13.307	-	13.307
Total Adjustments	-0.358	0.000	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.358	0.000			
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000

Change Summary Explanation

Technical: Not applicable.

Schedule: Not applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603651M / *JT Non-Lethal Wpns Tech Dev*	Project (Number/Name) 3022 / *Joint Non Lethal Weapons*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
3022: *Joint Non Lethal Weapons*	0.000	13.090	13.313	13.307	-	13.307	13.301	13.564	13.840	14.116	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project funds the research and development of next-generation Non-Lethal Weapons and includes performing analysis, technical development efforts, and modeling and simulation necessary to ensure optimum weaponization and use of these NLWs. Investment areas include research and development of next-generation Non-Lethal Weapons (NLW) such as: non-lethal directed energy weapons (lasers, millimeter wave and high power microwave) for counter-personnel and counter-materiel missions; non-lethal counter-personnel technologies (acoustic, optical, and human electro-muscular disruption technologies), and advanced non-lethal materiels (including materiels for vehicle/vessel stopping and counter-facility applications). Next-generation Non-Lethal Weapon systems focus on long-range localized Non-Lethal effects to identified threat individuals (or groups of individuals) and/or their threat weapons systems operating in complicated environments such as urban areas, crowds, buildings, vehicles, vessels, and also in close proximity to high-value civilian facilities.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: JOINT NON-LETHAL WEAPONS	13.090	13.313	13.307	0.000	13.307
FY 2019 Plans: Continue the development, integration, and demonstration of advanced technologies and payloads capable of addressing non-lethal counter-personnel and counter-materiel capability gaps while minimizing risk to the operator. Development efforts include the prototyping of advanced payloads, delivery systems, alternative technologies, and high power microwave component hardware and modular systems for non-lethal vehicle and vessel stopping applications. Development and integration of advanced solid-sate and vacuum-tube based millimeter wave technologies for counter-personnel directed energy effects. Continue to reduce weapon system size, weight, power consumption, thermal cooling requirements, and overall system cost to improve military utility. Continue human effects modeling and analysis efforts to incorporate knowledge gained from applied research studies into a suite of programs and surrogates that enable assessment and prediction of injury risk and effectiveness for NLW stimuli. Transition prototype technologies offering operational utility to higher levels of technology development and acquisition.					
FY 2020 Base Plans: Advance the development, integration, and demonstration of advanced technologies and payloads capable of addressing non-lethal counter-personnel and counter-materiel capability gaps while minimizing risk to the operator. Development efforts include the prototyping of: (1) a next-generation long range - long duration wireless Human Electro-Muscular Incapacitation munition; (2) short pulse source and other high power microwave waveforms that are effective against threat vehicle, vessel, and other target with embedded					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603651M / *JT Non-Lethal Wpns Tech Dev*	**Project (Number/Name)** 3022 / *Joint Non Lethal Weapons*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
electronic systems; (3) longer range but more compact millimeter wave technologies capable of being integrated and tested on future escalation of force platforms; and (4) improved sound and light and non-lethal laser technologies. This includes the development and integration of advanced solid-state and vacuum-tube based millimeter wave technologies for counter-personnel directed energy effects. Continue human effects modeling and analysis efforts to incorporate risk of significant injury knowledge of specific next-generation NLWs currently under development and utilizing new non-lethal stimuli and phenomenologies. Transition prototype technologies offering operational utility to higher levels of technology development and acquisition. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Accomplishments/Planned Programs Subtotals	13.090	13.313	13.307	0.000	13.307

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

The primary objective of this Program Element is the development of technologies that lead to the next-generation of Non-Lethal Weapons which address identified and prioritized joint Non-Lethal Weapon capability gaps. The program consists of a collection of projects for the development and evaluation of feasibility demonstration models. Individual project metrics reflect the technical goals of each specific project. Typical metrics include both the effectiveness of the technology, human effects and effectiveness, mitigation of high priority joint NLW capability gaps, and potential for compliance with policy and legislation. Overarching considerations include the advancement of related Technology Readiness Levels and Human Effects Readiness Levels, the degree to which project investments are leveraged with other performers, reduction in life cycle cost upon application of the technology, and the identification of opportunities to transition technology to higher categories of development.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603673N *I (U)Future Naval Capabilities Advanced Tech Dev*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	215.946	214.184	231.907	-	231.907	281.953	277.461	273.380	278.874	Continuing	Continuing
3346: *Future Naval Capabilities Adv Tech Dev*	0.000	215.946	206.684	231.907	-	231.907	281.953	277.461	273.380	278.874	Continuing	Continuing
9999: *Congressional Adds*	0.000	0.000	7.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	7.500

A. Mission Description and Budget Item Justification

The Future Naval Capabilities (FNC) program represents the requirements-driven, delivery-oriented piece of the Department of the Navy (DON) Science and Technology (S&T) portfolio. The efforts described in this Program Element (PE) address the Advanced Technology Development associated with the FNC Program. The objective of the work in this PE is to develop promising technologies emerging from the FNC Applied Research program that have successfully matured to higher Technology Readiness Levels (TRLs).

The FNC Program was restructured for FY19 to accelerate transition to the Fleet and Force. This restructuring involved a zero based review of all ongoing FNC projects, where each effort was assessed for its technology maturity and transition commitment. Ongoing efforts were categorized as FNCs or Technology Candidates. Some efforts were terminated and others were accelerated to achieve the goals of the restructured program. Funding for FNCs, which have higher Technology Readiness Levels (TRLs of 4/5 to 6) and transition funding commitments, are being resourced in this PE, 0603673N Future Naval Capabilities Advanced Technology Development. ONR is coordinating closely with the resource Sponsors and acquisition stakeholders to develop high priority technological capabilities needed by the operational forces.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	231.772	232.996	230.269	-	230.269
Current President's Budget	215.946	214.184	231.907	-	231.907
Total Adjustments	-15.826	-18.812	1.638	-	1.638
• Congressional General Reductions	-	-0.209			
• Congressional Directed Reductions	-	-26.103			
• Congressional Rescissions	-	-			
• Congressional Adds	-	7.500			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-3.746	0.000			
• Program Adjustments	0.000	0.000	1.638	-	1.638
• Rate/Misc Adjustments	-0.001	0.000	0.000	-	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy					Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*		R-1 Program Element (Number/Name) PE 0603673N *I (U)Future Naval Capabilities Advanced Tech Dev*			
• Congressional General Reductions Adjustments	-0.144	-	-	-	-
• Congressional Directed Reductions Adjustments	-11.935	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Advanced Development of High Yield Conventional Energetics*	0.000	7.500
Congressional Add Subtotals for Project: 9999	0.000	7.500
Congressional Add Totals for all Projects	0.000	7.500

Change Summary Explanation

The program increase in FY 2020 responds to increase demand to develop technologies for transition to Programs of Record.

Technical: Not applicable.

Schedule: Not applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603673N / *(U)Future Naval Capabilities Advanced Tech Dev*	Project (Number/Name) 3346 / *Future Naval Capabilities Adv Tech Dev*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
3346: *Future Naval Capabilities Adv Tech Dev*	0.000	215.946	206.684	231.907	-	231.907	281.953	277.461	273.380	278.874	Continuing	Continuing

A. Mission Description and Budget Item Justification

Prior to FY19, Future Naval Capabilities (FNC) Program investments were selected almost two years in advance of execution. It was determined by Navy and Marine Corps leadership that this approach limits Department of the Navy's (DON) ability to exploit technology advances and respond quickly to naval needs. As a result, future Budget Activity (BA) 3 investments supporting the FNC Program are now made less than one year before commencing execution. Because FNCs are now starting at higher Technology Readiness Levels (TRL), the typical duration of an FNC has been shortened to 3-years. The FNC Program has been fully restructured in favor of a more direct and higher level of collaboration. Program Element R-2 Activities were modified for FY19 to align to warfare areas and the corresponding resource sponsors that will integrate FNC technologies into acquisition programs of record. These R-2 Activities have been continued into FY20.

A complete accounting of the technologies being developed and a full disposition of each technology development effort will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: CAPABLE MANPOWER (CMP)	17.624	7.514	10.640	0.000	10.640
Description: The Capable Manpower R-2 Activity, modified for FY19, focuses on the advanced technology development of new capabilities that leverage the underlying applied research investments in Program Element (PE) 0602750N Future Naval Capabilities (FNC) Applied Research. These advanced technology investments align to acquisition programs of record principally under the purview of Deputy Chief of Naval Operations (CNO) for Manpower, Personnel, Training and Education and Marine Corps Training and Education Command (TECOM). ***FY 2019 Plans:*** The advanced technologies being developed under this R-2 Activity include efforts that focus on the future integrated training environment for integrated air and ground operations of the marine air-ground task force, learning continuum and performance aids, manpower, personnel and training strategic planning, simulation tailored training and assessments, decision making and learning management systems, an assessment process for the selection of unmanned aerial systems personnel, simulation toolsets for analysis of mission, personnel and systems that includes techniques to optimize manpower planning, next generation perceptual training systems and tools, augmented immersive team training, behavioral and performance analysis for intelligent					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603673N / *(U)Future Naval Capabilities Advanced Tech Dev*	**Project (Number/Name)** 3346 / *Future Naval Capabilities Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
training, advanced technologies for automated performance assessment in games and tools for game-based training and assessment of human performance. ***FY 2020 Base Plans:*** The advanced technologies being developed under this R-2 Activity in FY20 include technologies supporting the future integrated training environment and ready relevant learning. Training simulator software and hardware to support the rapid integration and interoperability of air and ground legacy and future simulation-based training is being developed to address the shortfall in sorties needed to maintain readiness for integrated air and ground operations of the marine air-ground task force. This technology will allow pilots and aircrews to train effectively in a common, simulated operating environment. Flexible and interoperable learning continuum and performance aids will be developed, providing individual career management, skill classification, selection, automatic training content re-engineering, supervisor evaluations, and Fleet readiness tracking. New machine learning algorithms will input training data from the lifelong learning record, and output a training model that is usable for adaptive training. The focus on ready relevant training will accelerate learning, reduce the decay of acquired skills, and provide readiness tracking of performance at an individual level. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase from FY 2019 to FY 2020 was due to an increased investment in technologies supporting the future integrated training environment and ready, relevant training. A complete accounting of the technologies being developed and a full disposition of each technology development effort will be provided separately to the Congressional oversight committees.					
Title: ENTERPRISE AND PLATFORM ENABLERS (EPE) ***Description:*** The investments that would have continued in this R-2 Activity have been moved into the activities of the restructured Future Naval Capabilities (FNC) Program. ***FY 2019 Plans:*** N/A ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:***	14.301	0.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603673N / *(U)Future Naval Capabilities Advanced Tech Dev*	**Project (Number/Name)** 3346 / *Future Naval Capabilities Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** N/A					
Title: EXPEDITIONARY MANEUVER WARFARE (EMW) ***Description:*** The Expeditionary Maneuver Warfare R-2 Activity, modified for FY19, focuses on the advanced technology development of new capabilities that leverage the underlying applied research investments in PE 0602750N, Future Naval Capabilities (FNC) Applied Research. These advanced technology investments align to acquisition programs of record principally under the purview of the Deputy Commandant for Combat Development and Integration (CD&I) and the Director of Expeditionary Warfare. ***FY 2019 Plans:*** The advanced technologies being developed under this R-2 Activity include those efforts that focus on autonomous unmanned surface vehicles for mine warfare, off-board refueling and data transfer for unmanned surface vehicles, automated data analysis for expeditionary Mine Countermeasures (MCM), advanced undersea weapon systems for mine warfare, ground based air defense on-the-move high energy laser systems, advanced sonar technology for high clearance rate MCM, defense of harbor and near-shore naval infrastructure against asymmetric threats, fuel efficient tactical vehicles, renewable and sustainable expeditionary power, exchange of actionable information at the tactical edge, actionable intelligence enabled by persistent surveillance, densified propellants for fire from enclosed/confined spaces, spectral and reconnaissance imagery, azimuth and inertial navigation systems, counter radio-controlled improvised explosive device electronic warfare, and precision universal mortars. ***FY 2020 Base Plans:*** The advanced technologies being developed under this R-2 Activity in FY20 include those efforts that focus on Mine Countermeasures (MCM) task force planning, multi-mission airborne mine detection, and mine neutralization without collateral damage. Mission management tools will be developed for the Mine Countermeasures Commander to assist in the planning and re-planning, scheduling, and allocation of MCM task force assets using an extremely modular, open systems approach. This will provide MCM Commanders with the ability to rapidly re-plan and schedule emerging LCS/MCM Mission Package assets and maintain situational awareness of heterogeneous groups of systems. The investment in single-system, day/night, multi-mission airborne mine detection technologies usable at all water depths will be increased in order to reduce the MCM timeline and facilitate our capability to counter surface/near surface mines in the Surf Zone or Beach	0.000	5.840	22.399	0.000	22.399

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603673N / *(U)Future Naval Capabilities Advanced Tech Dev*	**Project (Number/Name)** 3346 / *Future Naval Capabilities Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Zone (BZ) at night. The viability of the preliminary design and schedule to support Fire Scout integration will be thoroughly explored. New mine neutralization technologies will enhance the effectiveness and efficiency of Navy expeditionary force capabilities in their assigned response mission to counter naval mine and maritime improvised explosive device threats. This technology will enhance the capability of the Maritime Expeditionary Standoff Response (MESR) System of Systems. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase from FY 2019 to FY 2020 reflects an increased investment in multi-mission airborne mine detection technologies that offer the potential for a significant reduction in the MCM timeline, and an investment in new mine neutralization technologies countering naval mine and maritime improvised explosive device threats. This increase includes specific and substantial ramp-up in FY 2020 for the Single-system Multi-mission Airborne Mine Detection (SMAMD) effort and initiating the Low Observable No Collateral Damage - Neutralization (LONCD-N) System development. A complete accounting of the technologies being developed and a full disposition of each technology development effort will be provided separately to the Congressional oversight committees.					
Title: FORCE HEALTH PROTECTION (FHP)	10.717	0.802	0.000	0.000	0.000
Description: The Force Health Protection R-2 Activity focuses on the advanced technology development of new capabilities that leverage the underlying applied research investments in Program Element (PE) 0602750N, Future Naval Capabilities (FNC) Applied Research. These advanced technology investments align to programs under the purview of the Surgeon General of the Navy and the Defense Health Agency. ***FY 2019 Plans:*** The advanced technologies being developed under this R-2 Activity include those efforts that focus on enabling new practices, procedures, medical devices and pharmaceuticals for the improvement of personnel performance, casualty prevention and combat casualty care. These technologies aim to decrease the logistical burden of forward medical operations, mitigate and prevent combat-related illness and injury, and provide cutting-edge medical applications for Navy and Marine Corps warfighters on land, at sea, and in the air. ***FY 2020 Base Plans:***					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603673N / *(U)Future Naval Capabilities Advanced Tech Dev*	**Project (Number/Name)** 3346 / *Future Naval Capabilities Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
N/A ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The decrease from FY19 to FY20 was due to the completion of an FNC system that predicts, detects, and warns warfighters of hypoxia in a way that accounts for individual tolerance differences. A complete accounting of the technologies being developed and a full disposition of each technology development effort will be provided separately to the Congressional oversight committees.					
Title: FORCENET (FNT) ***Description:*** The investments that would have continued in this R-2 Activity have been moved into the activities of the restructured Future Naval Capabilities (FNC) Program. ***FY 2019 Plans:*** N/A ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** N/A	60.565	0.000	0.000	0.000	0.000
Title: POWER AND ENERGY (P&E) ***Description:*** The investments that would have continued in this R-2 Activity have been moved into the activities of the restructured Future Naval Capabilities (FNC) Program. ***FY 2019 Plans:*** N/A ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:***	12.590	0.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603673N / *(U)Future Naval Capabilities Advanced Tech Dev*	**Project (Number/Name)** 3346 / *Future Naval Capabilities Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** N/A					
Title: SEA SHIELD (SHD) ***Description:*** The investments that would have continued in this R-2 Activity have been moved into the activities of the restructured Future Naval Capabilities (FNC) Program. ***FY 2019 Plans:*** N/A ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** N/A	55.745	0.000	0.000	0.000	0.000
Title: SEA STRIKE (STK) ***Description:*** The investments that would have continued in this R-2 Activity have been moved into the activities of the restructured Future Naval Capabilities (FNC) Program. ***FY 2019 Plans:*** N/A ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** N/A	44.404	0.000	0.000	0.000	0.000
Title: AIR WARFARE (AW)	0.000	35.214	38.871	0.000	38.871

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603673N / *(U)Future Naval Capabilities Advanced Tech Dev*	**Project (Number/Name)** 3346 / *Future Naval Capabilities Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Description: The Air Warfare R-2 Activity, focuses on the advanced technology development of new capabilities that leverage the underlying applied research investments in Program Element (PE) 0602750N, Future Naval Capabilities (FNC) Applied Research. These advanced technology investments align to acquisition programs of record principally under the purview of the Director of Air Warfare. ***FY 2019 Plans:*** The advanced technologies being developed under this R-2 Activity include those efforts that focus on extended range targeting, advanced protection from infrared and electro-optic threats, radar electronic attack protection, intelligent collaborative engagements, multifunction capabilities for missile warning sensors, advanced threat aircraft countermeasures, technologies that discriminate and provide terminal guidance for weapons that engage moving targets, numerous advanced weapons technologies, high altitude Anti-Submarine Warfare (ASW), placement and operation of active ASW distributed systems, data exfiltration and networked platform interaction, advanced topcoat systems for air vehicles, air platforms safety and affordability technologies, virtual-constructive representations on live avionics displays for training, and dynamic adaptive and modular training for unmanned aerial systems. ***FY 2020 Base Plans:*** The advanced technologies being developed under this R-2 Activity in FY20 include those efforts that focus on enhanced corrosion protection for aircraft surfaces and galvanic interfaces in order to improve durability and reduce toxicity/exposures, advanced radio enhancements for long range anti-ship missiles and other weapons, human machine interface and vehicle controller command and control technologies that implement full and partial UxV transfer of control and discovery, software performance assessment tools to automatically collect, fuse, display, analyze, and archive live virtual constructive training data from disparate systems, and multi-platform technologies for collaborative airborne manned and unmanned tactical electronic warfare operations at all jamming ranges. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase from FY 2019 to FY 2020 reflects the initiation of new FNCs involving unmanned vehicle control software, live virtual constructive training, and collaborative electronic warfare technologies. A complete					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603673N / *(U)Future Naval Capabilities Advanced Tech Dev*	**Project (Number/Name)** 3346 / *Future Naval Capabilities Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
accounting of the technologies being developed and a full disposition of each technology development effort will be provided separately to the Congressional oversight committees.					
Title: INFORMATION WARFARE (IW)	0.000	74.446	61.814	0.000	61.814
Description: The Information Warfare R-2 Activity, focuses on the advanced technology development of new capabilities that leverage the underlying applied research investments in Program Element (PE) 0602750N, Future Naval Capabilities (FNC) Applied Research. These advanced technology investments align to acquisition programs of record principally under the purview of the Deputy Chief of Naval Operations for Information Warfare. ***FY 2019 Plans:*** The advanced technologies being developed under this R-2 Activity cover rapidly evolving technological areas and include those that focus on next-generation command, control and decision support services, cyber security, cyber operations, real-time engagement coordination and performance estimation, next generation countermeasure technologies for ship missile defense, extended distributed weapons coordination, cross field processing and smart use of distributed systems, network collaborative precision navigation and timekeeping, communications and interoperability for integrated fires, shipboard panoramic infrared and electro-optic cueing and surveillance systems, a tactical cloud that exploits cross warfare area data sources, electronic warfare battle management for surface defense, autonomous persistent tactical surveillance, mission-based waveform controls and networking, satellite vulnerability mitigation, comprehensive maritime operational and navigational planning via decision support services, collaborative algorithms for non-Global Positioning System (GPS)-based navigation, technologies that enable real-time situational awareness of tactic-edge Internet Protocol (IP) networks operating in contested environments, technologies enabling coordination between shipboard and expendable Electro-Optical/Infrared (EO/IR) countermeasures, automation technologies that improve theater level anti-submarine warfare operations and multi-domain battle management capabilities. ***FY 2020 Base Plans:*** The advanced technologies being developed under this R-2 Activity in FY20 cover rapidly evolving technological areas and include those that: a)enable distributed and networked sensor and weapon control by providing a communications interface for combat systems applications, b) deliver data and information via any combination of available tactical data links, c) enhance security, d) provide an improved capability to detect and track the newest generation of ultra-quiet submarines in the deep ocean, e) provide the surface fleet with a position fixing capability in a Global Positioning System (GPS) denied environment, f) correlate multi-sensor, multi-platform, radio-frequency, geo-location data to create a passive common operating picture and enable coordinated					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603673N / *(U)Future Naval Capabilities Advanced Tech Dev*	**Project (Number/Name)** 3346 / *Future Naval Capabilities Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
engagements of multi-mode, multi-aspect, threat sensors using networked tactical electronic warfare and information operations systems, g) build on networked electronic warfare infrastructures to provide new user interfaces for multi-platform, coordinated electronic support and electronic attack techniques, h) sense and assess real-time environmental conditions to improve sensor performance forecasting and automate the detection of very quiet targets within undersea surveillance barriers, and i) develop technologies that can be demonstrated in an 'A'-size sonobuoy capable of delivering the array gain required to localize and collect passive acoustic intelligence of ultra-quiet submarines at tactically relevant ranges through exploitation of a unique feature of the sound channel. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The decrease from FY 2019 to FY 2020 was due to the completion and delivery to acquisition programs of record of several Future Naval Capabilities (FNC) that successfully demonstrated a Technology Readiness Level (TRL) of 6, including the FNCs providing a tactical cloud capability that exploit cross warfare area data sources and a means to detect and measure incoming threats. A complete accounting of the technologies being developed and a full disposition of each technology development effort will be provided separately to the Congressional oversight committees.					
Title: SURFACE WARFARE (SW) ***Description:*** The Surface Warfare R-2 Activity, focuses on the advanced technology development of new capabilities that leverage the underlying applied research investments in Program Element (PE) 0602750N, Future Naval Capabilities (FNC) Applied Research. These advanced technology investments align to acquisition programs of record principally under the purview of the Director of Surface Warfare. ***FY 2019 Plans:*** The advanced technologies being developed under this R-2 Activity include those efforts that focus on hyper velocity projectiles, full sector torpedo defense, cooperative networked radars, sonar automation, radar resource management for integrated air and missile defense, periscope detection and discrimination, high fidelity active sonar training, anti-ship missile defense, long range detection and tracking, naval interceptor improvements, unmanned systems common control, digital array radars, multifunction shipboard energy storage and power distribution, high power solid state circuit protection, compact power conversion for advanced surface machinery systems, resilient hull and infrastructure mechanical and electrical security, phased array antennas, human injury	0.000	32.656	46.824	0.000	46.824

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603673N / *(U)Future Naval Capabilities Advanced Tech Dev*	**Project (Number/Name)** 3346 / *Future Naval Capabilities Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
and treatment models, aluminum alloy corrosion control and prevention, affordable common radar architectures, total ship survivability damage tolerance and recoverability, adaptive training to enhance individual and team learning, and platform design and acquisition tools that reduce manpower. ***FY 2020 Base Plans:*** The advanced technologies being developed under this R-2 Activity in FY20 include those efforts that focus on: a) high density, modular and configurable, high cycle rate, megawatt-scale multifunction energy storage systems for electric weapons and sensor loads that are necessary to provide continuous operational availability, b) the integration testing necessary to implement attack resilient architectures and toolsets that can be retrofitted to both legacy and modern shipboard control systems, c) the incorporation of high density reactive materials into warheads such as the ALaMO 57mm round so as to significantly increase lethality without requiring changes to flight dynamics, guidance, and/or interaction with the respective weapon system, d) advanced alloys and airfoil coatings for Gas Turbine hot section components that will realize a 3X improvement in engine life at higher operating temperatures and pressures, improving the mean time between failure of these expensive ship engines, e) technologies that counter unmanned aerial surveillance drones, f) a new in-situ electrodeposition repair process to coat heat exchanger tubing surfaces with materials and alloys that restore and improve the integrity of damaged Cu-Ni tubing, g) training for staffs and operators required to conduct command and control against peer threats in degraded and denied environments, h) a new electronic initiation safety device for energetic initiation for both SM-6 and SM-2 upgrades, i) a receive-only capability on SPY-6V1 for improved situational awareness during EMCON and improved radar timelines with advanced waveforms for communications and radar operation, and j) modular virtual-constructive simulation technologies, realistic phenomenology and behavior models for synthetic entities in support of warfighter command Ttam and platform operator staff multi-mission training, assessment and certification. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase from FY 2019 to FY 2020 enables the initiation of new FNCs for in-situ repair of heat exchanger tubing, training for operations in command and control denied or degraded environments, a new electronic initiation safety device for the SM-2 and SM-6, and receive-only SPY-6V1 improvements. A complete accounting of the technologies being developed and a full disposition of each technology development effort will be provided separately to the Congressional oversight committees.					
Title: UNDERSEA WARFARE (UW)	0.000	50.212	51.359	0.000	51.359

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603673N / *(U)Future Naval Capabilities Advanced Tech Dev*	**Project (Number/Name)** 3346 / *Future Naval Capabilities Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Description: The Undersea Warfare R-2 Activity, focuses on the advanced technology development of new capabilities that leverage the underlying applied research investments in Program Element (PE) 0602750N, Future Naval Capabilities (FNC) Applied Research. These advanced technology investments align to acquisition programs of record principally under the purview of the Director of Undersea Warfare. ***FY 2019 Plans:*** The advanced technologies being developed under this R-2 Activity include those efforts that focus on extended range modular undersea heavyweight vehicle technology for submarine-launched torpedoes, coherent electronic attack capabilities for submarines, vector sensors and signal processing for acoustic arrays, panoramic infrared sensors, technologies for rapid and covert surveillance, electronic sensors for detection of low probability of intercept periscope detection radars, torpedo advanced propulsion systems, simultaneous transmit and receive capabilities for submarines, scalable integrated radio frequency systems for undersea platforms, electronic warfare tactical decision aids, tools for predicting array operational loading and distribution, acoustic damping systems, corrosion mitigation technologies that increase operational availability, panoramic photonics mast technologies, hyper-spectral scanning imagery, low light level video cameras, new material development and lab characterization, unmanned aerial system control technologies, adaptive training for submarine navigation and piloting, signature management technologies, and information architectures for improved decision making. ***FY 2020 Base Plans:*** The advanced technologies being developed under this R-2 Activity in FY20 include those efforts that focus on a) simultaneous transmit and receive capabilities for radio frequency antenna apertures as well as the backend processing that enable stealthy submarine information operation missions, b) an integrated combat capability to the Submarine Payload Control System that supports collaborative planning, payload coordination, briefing, and enhanced mission execution through seamless integration with the unmanned vehicle controller, c) reducing the signature of current and future submarines in order to enhance their military effectiveness, d) automated data analysis for expeditionary mine countermeasures, e) a modular and adaptive electronic warfare trainer, scenario generator and digital stimulator that's applicable to multiple training facilities and air, surface, and undersea platforms, f) high performance submersible radar absorbing structures that use advanced manufacturing techniques to improve affordability, durability, scalability, and the performance of submarine mast materials, and g) technologies offering a covert broadband acoustic signal structure with advanced processing algorithms that will increase an SSBN's ability to conduct bathymetric fixes in a wider range of operational environments. ***FY 2020 OCO Plans:***					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603673N / *(U)Future Naval Capabilities Advanced Tech Dev*	**Project (Number/Name)** 3346 / *Future Naval Capabilities Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase from FY 2019 to FY 2020 supports completion and delivery to acquisition programs of record of several Future Naval Capabilities (FNC) including tools for predicting array operational loading/distribution and heavyweight torpedo improvements. A complete accounting of the technologies being developed and a full disposition of each technology development effort will be provided separately to the Congressional oversight committees.					
Accomplishments/Planned Programs Subtotals	215.946	206.684	231.907	0.000	231.907

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

The performance metric for this Program Element (PE) is measured by the number of FNCs that transition through an acquisition POR to deploy new capabilities into the Fleet or Force.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603673N / *(U)Future Naval Capabilities Advanced Tech Dev*	Project (Number/Name) 9999 / *Congressional Adds*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	0.000	7.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	7.500

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other projects

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Advanced Development of High Yield Conventional Energetics	0.000	7.500
FY 2018 Accomplishments: N/A		
FY 2019 Plans: FY19 funds will be used towards the advanced demonstration of energetic materials in a variety of weapon system applications to include: high performance solid rocket and air breathing propulsion, reactive materials demonstrations and effects in advanced lethality and effectiveness models,advanced warhead concepts to include novel reactive shaped charge configurations, hybrid reactive material warhead demonstrations, and the development and demonstration of any necessary modeling and simulation capabilities for quantification of damage effects on adversary weapon systems,and other potential energetic technologies.		
Congressional Adds Subtotals	0.000	7.500

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other projects

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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603680N *I (U)Manufacturing Technology Program*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	66.173	58.657	60.138	-	60.138	60.122	61.318	62.582	63.840	Continuing	Continuing
1050: *Manufacturing Tech*	0.000	56.516	58.657	60.138	-	60.138	60.122	61.318	62.582	63.840	Continuing	Continuing
9999: *Congressional Adds*	0.000	9.657	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	9.657

A. Mission Description and Budget Item Justification

The Manufacturing Technology (ManTech) Program is intended to improve the productivity and responsiveness of the U.S. defense industrial base by funding the development, optimization, and transition of enabling manufacturing technologies to key naval suppliers. In general, investments transition emerging Science and Technology (S&T) results to acquisition programs; improve industrial capabilities in production, maintenance, repair and industrial base responsiveness; and advance manufacturing technology to reduce cost, improve performance, and responsiveness. Currently, the ManTech Program is focused on affordability improvements for specific key acquisition platforms as defined in the Navy ManTech Investment Strategy. Key platforms currently targeted include: VIRGINIA Class Submarine (VCS)/ OHIO Replacement Program (ORP); DDG 51 Class Destroyer; CVN 78 Class Carrier; Joint Strike Fighter (JSF); and CH-53K Heavy Lift Helicopter. Office of Naval Research (ONR) ManTech helps these Navy programs achieve their respective affordability goals by transitioning developed manufacturing technology which, when implemented, results in needed cost reduction or cost avoidance.

Due to the number of efforts in this Program Element (PE), the programs described herein are representative of the work included in this PE.

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	57.797	58.657	60.500	-	60.500
Current President's Budget	66.173	58.657	60.138	-	60.138
Total Adjustments	8.376	0.000	-0.362	-	-0.362
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.625	0.000			
• Rate/Misc Adjustments	0.001	0.000	-0.362	-	-0.362
• Congressional Add Adjustments	10.000	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603680N *I (U)Manufacturing Technology Program*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Congressional Add: *Program Increase*	9.657	0.000
Congressional Add Subtotals for Project: 9999	9.657	0.000
Congressional Add Totals for all Projects	9.657	0.000

Change Summary Explanation

The increase from FY 2019 to FY 2020 is to perform additional technology development efforts to support the submarine industrial base ramp up and workload increase for VIRGINIA Payload Module and COLUMBIA Class Submarine production in addition to the continuing VIRGINIA Class Submarine 2 per year production.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603680N / *(U)Manufacturing Technology Program*	Project (Number/Name) 1050 / *Manufacturing Tech*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
1050: *Manufacturing Tech*	0.000	56.516	58.657	60.138	-	60.138	60.122	61.318	62.582	63.840	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Manufacturing Technology (ManTech) Program is intended to improve the productivity and responsiveness of the U.S. defense industrial base by funding the development, optimization, and transition of enabling manufacturing technologies to key naval suppliers. In general, investments transition emerging Science and Technology (S&T) results to acquisition programs; improve industrial capabilities in production, maintenance, repair and industrial base responsiveness; and advance manufacturing technology to reduce cost, improve performance, and responsiveness. Currently, the ManTech Program is focused on affordability improvements for specific key acquisition platforms as defined in the Navy ManTech Investment Strategy. Key platforms currently targeted include: VIRGINIA Class Submarine (VCS)/ COLUMBIA Class Submarine (CLB); DDG 51 Class Destroyer; CVN 78 Class Carrier; Joint Strike Fighter (JSF); and CH-53K Heavy Lift Helicopter. Office of Naval Research (ONR) ManTech helps these Navy programs achieve their respective affordability goals by transitioning developed manufacturing technology which, when implemented, results in needed cost reduction or cost avoidance.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: Composites Processing and Fabrication	8.000	8.000	8.000	0.000	8.000
Description: The primary technical goal of the Composites Processing and Fabrication activity is improving weapon systems affordability, enhancing weapon system effectiveness and improving reliability/war-fighter readiness through the increased utilization of composite materials and structures. This is being achieved through the development, maturation, and transition of affordable and robust manufacturing, assembly, and repair processes that fully exploit the benefits of composite materials. Concentration is on affordability for the following platforms: VIRGINIA Class Submarine (VCS)/COLUMBIA Class Submarine (CLB), DDG 51 Class Destroyer, CVN 78 Class Carrier, Joint Strike Fighter (JSF), and CH-53K Heavy Lift Helicopter. Composites processing and fabrication technology areas include but are not limited to fiber-reinforced polymeric (organic) resin composites; ceramic-matrix, metal-matrix, and carbon-carbon composites; composite internal stiffening core materials such as foam, ceramic, balsa wood, polymeric or metallic honeycomb, or other materials; composite external stiffening concepts such as hat and blade stiffeners and methodologies to manufacture them; materials for radomes and other electrical applications; composite manufacturing and similar processes and related equipment technology; and adhesives, adhesive bonding, and related technologies (i.e., surface preparation techniques), as well as mechanical fastening, and other methodologies for joining composites to other composites or metals, and similar assembly technologies.					
FY 2019 Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603680N / *(U)Manufacturing Technology Program*	**Project (Number/Name)** 1050 / *Manufacturing Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Continue Composite Materials and Process Improvement Thrust and fabrication efforts for VCS/ORP, CVN 78, DDG51, JSF, CH-53K. Continue Composite Materials and Process Improvement Thrust for other high interest NAVSEA, NAVAIR, and Marine Corps platforms and components. Includes support of affordability initiatives for the six acquisition platforms in the Navy ManTech investment strategy. ***FY 2020 Base Plans:*** Technical activities include (1) the design of a flexible robotic composites manufacturing cell for CH-53K fabrication for improved process repeatability, increased part quality, and reduced risk as production rates increase; (2) development of an improved and more affordable false deck panel concept for use in equipment spaces on DDG 51 Class destroyers constructed at both Bath Iron Works and HII-Ingalls and CVN 78 Class carriers constructed at HII-Newport News Shipbuilding; (3) development and proof of manufacturing technology for composite exhaust uptakes for the DDG 51 Class destroyers (for both Bath Iron Works and HII-Ingalls ships) for cost neutral or better acquisition cost, 60% reduction in maintenance costs, and 30% weight reduction; and (4) development of the equipment, processes, and methods needed to implement a system capable of fully automated optical inspection of MOD's (minor optical defects) on F-35 production transparencies and eliminate subjective, variable visual analysis currently done by individual operators. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no change in the requested budget from FY 2019 to FY 2020.					
Title: Electronics Processing and Fabrication	12.000	12.000	12.000	0.000	12.000
Description: The primary technical goal of the Electronics Processing and Fabrication activity is improving electronic weapon systems affordability by developing and transitioning affordable, robust manufacturing processes and capabilities for electronics critical to defense applications over their full life-cycle. Efforts create new and improved electronics/electro-optics manufacturing processes for transition to the production floor. Emphasis is on affordability for the following platforms: VIRGINIA Class Submarine (VCS)/COLUMBIA Class Submarine (CLB), DDG 51 Class Destroyer, CVN 78 Class Carrier, Joint Strike Fighter (JSF), and CH-53K Heavy Lift Helicopter. Electronics processing and fabrication technology areas include but are not limited to Electronics manufacturing technology (materials, devices, circuits, modules, subsystems); Semiconductor devices/vacuum electronics/passive components; compound semiconductors/wide bandgap semiconductors; low-cost, high-throughput manufacturing and assembly techniques; nanoelectronics; electronics packaging technologies (including tamper proof and non-hermetic approaches); optics manufacturing technology (materials					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603680N / *(U)Manufacturing Technology Program*	**Project (Number/Name)** 1050 / *Manufacturing Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
devices, circuits, modules, subsystems); optical interconnects; fiber optics and photonics; technologies for electronics and electro-optics testing and evaluation; optical imaging for manufacturing operations; and directed energy weapons. ***FY 2019 Plans:*** Continue Electronics/Electro-Optics Thrust and fabrication efforts for JSF, CH-53K, VCS/ORP, DDG51, CVN 78. Continue Electronics/Electro-Optics Thrust for other high interest NAVSEA, NAVAIR, and Marine Corps platforms and components. Includes support of affordability initiatives for the six acquisition platforms in the Navy ManTech investment strategy. ***FY 2020 Base Plans:*** Technical activities include (1) development of the technology to repurpose digital electronics currently used in the F-35 Joint Strike Fighter Active Electronically Scanned Array (AESA) radar system to accommodate Joint Strike Fighter (JSF) global positioning system (GPS) system functions with significantly improved anti-jamming capabilities; (2) development of a reduced cost manufacturing process for two of the most costly of seven elements in the optical train of the F-35 Helmet Mounted Display (HMD) Relay Optical Assembly (ROA) for the F-35 Joint Strike Fighter; (3) development of drone technology for the inspection of CVN 78 Class carrier tanks to replace currently used manual inspection techniques which are labor intensive, inefficient, and risky from a safety perspective; and (4) prototype a modern radar system architecture with open and common Radio Frequency (RF) components that demonstrate the capability to implement requirements for two significantly different radar systems to support the baseline for the Next Generation Surface Search Radar (NGSSR) for both CVN 79 Class carrier and DDG 51 Class destroyer. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no change in the requested budget from FY 2019 to FY 2020.					
Title: Metals Processing and Fabrication ***Description:*** The primary technical goal of the Metals Processing and Fabrication activity is to develop affordable, robust manufacturing and repair processes/capabilities for metals and special materials critical to Navy weapon system applications. Emphasis is on affordability for the following platforms: VIRGINIA Class Submarine (VCS)/COLUMBIA Class Submarine (CLB), DDG 51 Class Destroyer, CVN 78 Class Carrier, Joint Strike Fighter (JSF), and CH-53K Heavy Lift Helicopter. This activity also includes the development,	12.000	12.000	12.000	0.000	12.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603680N / *(U)Manufacturing Technology Program*	**Project (Number/Name)** 1050 / *Manufacturing Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
optimization, and transition of repair technology for the repair, overhaul, and sustainment of key navy systems. Metals processing and fabrication technology areas include but are not limited to: processing methods; metals additive manufacturing; metallic materials-based systems; casting; joining techniques; machining; surface and heat treatments; coating/cladding; assembly; metal/non-metals interfaces issues; and inspection and compliance verification. ***FY 2019 Plans:*** Continue Metals Processing Thrust and fabrication efforts for DDG51, CVN 78, CH-53K, VCS/OR and JSF. Continue Metals Processing Thrust for other high interest NAVSEA, NAVAIR, and Marine Corps platforms and components. Continue Repair Technology (RepTech) Thrust to develop, optimize, and transition repair technology for key naval platforms at depots and logistics centers. Includes support of affordability initiatives for the six acquisition platforms in the Navy ManTech investment strategy. ***FY 2020 Base Plans:*** Technical activities include (1) developing a manufacturing cell concept for the automated welding of submarine appendages (for both VIRGINIA and COLUMBIA construction) to replace the currently used manual approaches that are both labor-and time-intensive; (2) improvement of hull frame fabrication for the VIRGINIA and COLUMBIA Class submarines by developing and implementing a robotic solution that increases weld quality, decreases out-of-circularity fit up issues, and reduces the amount of welding and inspection man hours; and (3) improvement of foundry castings at HII-Newport News for CVN 78 Class carriers and VIRGINIA Class submarines by validating the use of shrouds to minimize air exposure of the molten metal and developing devices, procedures, and processes needed to implement the process with NNS legacy equipment and processes. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no change in the requested budget from FY 2019 to FY 2020.					
Title: Manufacturing Enterprise/Other	24.516	26.657	28.138	0.000	28.138
Description: The Manufacturing Enterprise/Other activity includes: (1) efforts targeted towards improving, in general, the manufacturing enterprise for the production of key naval platforms (both shipbuilding and aircraft); (2) energetic efforts; (3) naval research enterprise and laboratory support for key projects; and (4)					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603680N / *(U)Manufacturing Technology Program*	**Project (Number/Name)** 1050 / *Manufacturing Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
technical program support. Manufacturing Enterprise addresses the development, optimization, and transition of manufacturing enterprise technology to key naval platform suppliers. Emphasis is on affordability for the following shipbuilding platforms: VIRGINIA Class Submarine (VCS)/COLUMBIA Class Submarine (CLB), DDG 51 Class Destroyer, CVN 78 Class Carrier, Joint Strike Fighter (JSF), and CH-53K Heavy Lift Helicopter. Manufacturing enterprise technology areas include, but are not limited to design for easier production/design for manufacturability; development of build/assembly strategies; modeling and simulation technologies; model-based tools and approaches to optimize ease of production; intelligent manufacturing planning and factory execution; elimination of inefficiencies in design optimization, material usage, labor utilization, work flow, etc.; supply chain procedures and improvements (such as network centric manufacturing capabilities to facilitate resilient and adaptable supply chains); development of more efficient structural fabrication product lines; streamlining of outfitting operations; prediction and reduction of welding distortion; advanced automation and robotics for manufacturing; advanced data analytics, artificial intelligence and machine learning for production environments; and inspection technologies such as digital radiography and ultrasonic technologies. Energetics efforts concentrate on developing energetics solutions to ensure the availability of safe, affordable, and quality energetics products largely in support of Program Executive Office (PEO) Integrated Warfare Systems (IWS).					
FY 2019 Plans: Continue Manufacturing Enterprise Thrust and fabrication efforts for DDG, CVN 78, JSF and CH-53K. Continue Energetics Thrust for PEO IWS and Other Acquisition Programs. Included energetics efforts to support PEO IWS and other acquisition programs. Continue efforts to provide naval research enterprise and laboratory support for key projects. Continue efforts to provide technical engineering support for the ManTech Program. Includes support of affordability initiatives for the six acquisition platforms in the Navy ManTech investment strategy.					
FY 2020 Base Plans: Technical activities include (1) applying augmented reality (AR) and virtual reality (VR) by exploiting product model data to improve shipbuilding affordability for VIRGINIA Class and COLUMBIA Class (VCS and CLB) submarines, CVN 78 Class carrier, and DDG 51 Class destroyer; (2) creating a digital build sequence from the legacy VCS model to include the operations, material, joints, and views a worker needs to accomplish a particular unit of work to streamline both development time and rework required; and (3) develop Rapid Automated Technology Evaluation (RATE) capabilities for high rate automated F-35 aircraft assembly line automation processes to identify and predict any corrective actions necessary to not impact production schedules and product quality.					
FY 2020 OCO Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603680N / *(U)Manufacturing Technology Program*	**Project (Number/Name)** 1050 / *Manufacturing Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The Manufacturing Enterprise/Other activity is increasing from FY19 to FY20 in order to perform additional technology development efforts to support the submarine industrial base ramp up and workload increase for VIRGINIA Payload Module and COLUMBIA Class Submarine production in addition to the continuing VIRGINIA Class Submarine 2 per year production.					
Accomplishments/Planned Programs Subtotals	56.516	58.657	60.138	0.000	60.138

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Efforts are focused on affordability improvements (both acquisition and life-cycle) for specific key acquisition platforms as defined in the Navy ManTech Investment Strategy. Currently, the majority of Navy ManTech efforts are focused on affordability improvements for: VIRGINIA Class Submarine (VCS)/COLUMBIA Class Submarine (CLB), DDG 51 Class Destroyer, CVN 78 Class Carrier, Joint Strike Fighter (JSF), and CH-53K Heavy Lift Helicopter.

E. Performance Metrics

The ManTech Program's overall goal is to transition production technology to reduce the cost of Navy weapon systems. Metrics are currently collected on the cost savings per hull or per aircraft for each of the primary affordability platforms: VIRGINIA Class Submarine/COLUMBIA Class Submarine (VCS/CLB), DDG 51 Class Destroyer, CVN 78 Class Carrier, Joint Strike Fighter (JSF), and CH-53K Heavy Lift Helicopter.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603680N / *(U)Manufacturing Technology Program*	Project (Number/Name) 9999 / *Congressional Adds*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	9.657	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	9.657

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Program Increase	9.657	0.000
FY 2018 Accomplishments: This effort addressed shipbuilding affordability for the ships in the Navy ManTech investment strategy VIRGINIA Class Submarine (VCS)/COLUMBIA Class (CLB), DDG 51 Class Destroyer, and CVN 78 Class Carrier. The work focused on automation and robotics technology development, application and connection to product model data.		
FY 2019 Plans: N/A		
Congressional Adds Subtotals	9.657	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other Projects.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603729N *I Warfighter Protection Adv Tech*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	42.895	41.377	4.849	-	4.849	4.851	4.949	5.049	5.151	Continuing	Continuing
2914: *Warfighter Protection Adv Tech*	0.000	4.751	4.877	4.849	-	4.849	4.851	4.949	5.049	5.151	Continuing	Continuing
9999: *Congressional Adds*	0.000	38.144	36.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	74.644

A. Mission Description and Budget Item Justification

The efforts described in this Program Element (PE) are based on investment directions as defined in the Naval S&T Strategic Plan approved by the S&T Corporate Board. This strategy is based on needs and capabilities from Navy and Marine Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It provides the vision and key objectives for the essential science and technology efforts that will enable the continued supremacy of U.S. Naval forces in the 21st century. The Strategy focuses and aligns Naval S&T with Naval missions and future capability needs that address the complex challenges presented by both rising peer competitors and irregular/ asymmetric warfare.

This program supports the development and demonstration of field medical equipment and technologies to improve warfighter safety and to enhance personnel performance under adverse conditions. Navy investment in these areas is essential because Navy/USMC mission needs are not adequately addressed by the civilian sector or other Federal agencies.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Program Change Summary ($ in Millions)	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**
Previous President's Budget	4.878	0.000	0.000	-	0.000
Current President's Budget	42.895	41.377	4.849	-	4.849
Total Adjustments	38.017	41.377	4.849	-	4.849
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	41.377			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.482	0.000			
• Program Adjustments	0.000	0.000	4.849	-	4.849
• Rate/Misc Adjustments	-0.001	0.000	0.000	-	0.000
• Congressional Add Adjustments	39.500	-	-	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603729N *I Warfighter Protection Adv Tech*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *CW Bill Young Marrow Donor Program*	30.419	0.000
Congressional Add: *Novel Therapeutic Interventions Research*	7.725	5.000
Congressional Add: *Bone Marrow Registry Program*	0.000	31.500
Congressional Add Subtotals for Project: 9999	38.144	36.500
Congressional Add Totals for all Projects	38.144	36.500

Change Summary Explanation

No significant change between FY 2019 and FY 2020

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603729N / *Warfighter Protection Adv Tech*				Project (Number/Name) 2914 / *Warfighter Protection Adv Tech*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
2914: *Warfighter Protection Adv Tech*	0.000	4.751	4.877	4.849	-	4.849	4.851	4.949	5.049	5.151	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program supports the development and demonstration of field medical equipment, diagnostic capabilities and treatments; technologies to improve warfighter safety and to enhance personnel performance under adverse conditions; and systems to prevent occupational injury and disease in hazardous, deployment environments. Navy investment in these areas is essential because Navy/USMC mission needs are not adequately addressed by the civilian sector or other Federal agencies. For example, civilian emergency medicine does not address casualty stabilization during long transit times to definitive care. The National Institutes for Health (NIH) focuses on the basic science of disease processes and not product development. Programs are coordinated with other Services through the Armed Services Biomedical Research Evaluation and Management (ASBREM) Committee to prevent duplication of effort.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: NAVAL NOISE-INDUCED HEARING LOSS (NIHL)	4.751	4.877	4.849	0.000	4.849
Description: Improve Warfighter performance in high noise operational and training environments and reduce the incidence of auditory injuries.					
FY 2019 Plans: NOISE INDUCED HEARING LOSS: Conduct advanced research in medical prevention and treatment of NIHL and tinnitus. Investigate the incidence and susceptibility of NIHL and tinnitus, and evaluate mitigation strategies. Study the reduction of noise at the source, jet engine quieting and flight deck noise reduction and improve personal protective equipment technology.					
FY 2020 Base Plans: Develop advanced communication systems and platform quieting approaches for training and operational environments; develop in-ear dosimetry technologies to support the prediction of susceptibility/incidence of auditory damage, as well as the assessment of personal protective equipment; and advance infra-red therapy for the prevention and treatment of auditory injuries.					
FY 2020 OCO Plans: N/A					
FY 2019 to FY 2020 Increase/Decrease Statement:					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603729N / *Warfighter Protection Adv Tech*	**Project (Number/Name)** 2914 / *Warfighter Protection Adv Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
No significant change between FY 2019 and FY 2020					
Accomplishments/Planned Programs Subtotals	4.751	4.877	4.849	0.000	4.849

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Efforts within this PE are measured at two levels. At the lower level, each is measured against technical and financial milestones on a monthly basis. Annually, each project is reviewed in depth for technical and transition performance by the Chief of Naval Research (CNR).

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603729N / *Warfighter Protection Adv Tech*	Project (Number/Name) 9999 / *Congressional Adds*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	38.144	36.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	74.644

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: CW Bill Young Marrow Donor Program	30.419	0.000
FY 2018 Accomplishments: Bone Marrow program conducts research to develop hematopoietic cell transplants using "marrow' from unrelated donors, as well as to develop medical countermeasure to marrow toxic exposures. Program has five focus efforts: Triage Guidelines for Cytokine Administration Following a Radiological Disaster; Hematologic Laboratory Surge Network Exercise and Plan Development; Local Public Health Radiological Preparedness Gap Review and Tool Development Identification; Evaluation and identification of whole genome donor-recipient pair variation and donor-specific DNA methylation patterns that affect HCT outcomes; and Developing a Genomic Data Repository.		
FY 2019 Plans: N/A		
Congressional Add: Novel Therapeutic Interventions Research	7.725	5.000
FY 2018 Accomplishments: Novel Therapeutic Interventions Program conducts research on therapies that address readiness challenges by reducing battlefield mortality and improving quality of life. Research areas include treatment of injuries through the operational use of Platelet-Rich Plasma (PRP) and Bone Marrow Concentrate (BMC) for poly-trauma victims and use of new Bio-Motion techniques for treating musculoskeletal injuries.		
FY 2019 Plans: Novel Therapeutic Interventions Program conducts research on therapies that address readiness challenges by reducing battlefield mortality and improving quality of life. FY 19 efforts include utilizing a wearable garment to estimate strains/stresses in lower limbs during extreme exercises to determine joint susceptibility to microfractures, stress fractures, and potential ligament damage; development of a model of fluid resuscitation and physiology algorithm, and development in the use of platelet rich plasma (PRP) and bone marrow concentrate (BMC) for poly-traumatic injuries sustained during field operations		
Congressional Add: Bone Marrow Registry Program	0.000	31.500

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603729N / *Warfighter Protection Adv Tech*	**Project (Number/Name)** 9999 / *Congressional Adds*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
FY 2018 Accomplishments: N/A ***FY 2019 Plans:*** Bone Marrow program will develop, test and mature the ability to address contingency events wherein civilian or military personnel are exposed to marrow toxic agents, primarily ionizing radiation or chemical weapons containing nitrogen mustard in four focus areas: Contingency Preparedness, Development of Science and Technology for Rapid Identification of Matched Donors, Immunogenetic Studies in Transplantation and Clinical Research in Transplantation. Conduct efforts to develop and integrate framework, sensors and hardware platform for the real-time detection of acute ionizing radiation exposure and prediction of bone marrow injury to assist in the rapid identification of high risk personnel, assessment and triage, and pre-emptive donor matching for those requiring transplantation.		
Congressional Adds Subtotals	38.144	36.500

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other Projects.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy												Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603747N *I Undersea Warfare Advanced Tech*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	9.657	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	9.657
9999: *Congressional Adds*	0.000	9.657	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	9.657

A. Mission Description and Budget Item Justification

All Navy advanced technology development in undersea target detection, classification, localization, tracking and neutralization is funded through this Program Element (PE). The related technologies being developed are aimed at enabling Sea Shield, one of the three core operational concepts detailed in the Naval Transformational Roadmap. Associated efforts focus on new Anti-Submarine Warfare (ASW) operational concepts that promise to improve wide-area surveillance, detection, localization, tracking and attack capabilities against quiet adversary submarines operating in noisy and cluttered shallow water environments. The focus is on leveraging technologies that will protect the country's current capital investment in surveillance, submarine, surface ship and air ASW assets.

The efforts described in this Program Element PE are based on investment directions as defined in the Naval S&T Strategic Plan approved by the S&T Corporate Board (20 Jan 2015). This strategy is based on needs and capabilities from Navy and Marine Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It provides the vision and key objectives for the essential science and technology efforts that will enable the continued supremacy of U.S. Naval forces in the 21st century. The Strategy focuses and aligns Naval S&T with Naval missions and future capability needs that address the complex challenges presented by both rising peer competitors and irregular/asymmetric warfare.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Program Change Summary ($ in Millions)	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**
Previous President's Budget	0.000	0.000	0.000	-	0.000
Current President's Budget	9.657	0.000	0.000	-	0.000
Total Adjustments	9.657	0.000	0.000	-	0.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.343	0.000			
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
• Congressional Add Adjustments	10.000	-	-	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603747N *I Undersea Warfare Advanced Tech*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Unmanned Underwater Vehicle Research*	9.657	0.000
Congressional Add Subtotals for Project: 9999	9.657	0.000
Congressional Add Totals for all Projects	9.657	0.000

Change Summary Explanation

Technical: Not applicable.

Schedule: Not applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603747N / *Undersea Warfare Advanced Tech*	Project (Number/Name) 9999 / *Congressional Adds*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	9.657	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	9.657

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Unmanned Underwater Vehicle Research	9.657	0.000
FY 2018 Accomplishments: Funds used to develop and demonstrate cross-domain autonomous vehicle communications and autonomous behaviors for missions with undersea platforms.		
FY 2019 Plans: N/A		
Congressional Adds Subtotals	9.657	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other Projects.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603758N *I Navy Warfighting Exp & Demo*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	63.867	65.885	67.739	-	67.739	67.925	69.235	86.161	86.513	Continuing	Continuing
2918: *Navy Warfighting Experiments and Demo*	0.000	63.867	65.885	67.739	-	67.739	67.925	69.235	86.161	86.513	Continuing	Continuing

A. Mission Description and Budget Item Justification

This Program Element (PE) addresses the development of recent technology breakthroughs to meet current operational needs from a subscale proof-of-principle into a full-scale prototype for warfighter experimentation during laboratory and operational demonstrations, Fleet Battle Experiments (FBE), Limited Objective Experiments (LOEs) and sea trial exercises. The key aspects of this PE are divided into four areas: (1) SwampWorks develops and demonstrates newly invented or recently discovered technologies that address emergent and enduring operational problems in an accelerated timeframe; (2) ONR Experimentation (OE) develops rapid prototypes and provides them to the warfighter for experimentation during laboratory and operational demonstrations; (3) TechSolutions develops rapid response science and technology prototypes addressing Fleet/Force needs identified by Sailors and Marines at the deckplate level; (4) Operations Analysis provides the Navy and Marine Corps the means to identify capability needs that can be addressed with science and technology solutions; and (5) support for the Naval Precision Strike Operations, providing the Navy capability to quickly locate, target, and strike critical targets.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	64.889	0.000	0.000	-	0.000
Current President's Budget	63.867	65.885	67.739	-	67.739
Total Adjustments	-1.022	65.885	67.739	-	67.739
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	65.885			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.022	0.000			
• Program Adjustments	0.000	0.000	67.739	-	67.739
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000

Change Summary Explanation

Program change reflects return of original PE structure and increased investment in Precision Strike Technology

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603758N *I Navy Warfighting Exp & Demo*

Technical: Not applicable.

Schedule: Not applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603758N / *Navy Warfighting Exp & Demo*	Project (Number/Name) 2918 / *Navy Warfighting Experiments and Demo*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
2918: *Navy Warfighting Experiments and Demo*	0.000	63.867	65.885	67.739	-	67.739	67.925	69.235	86.161	86.513	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project focuses on the development of recent technology breakthroughs to meet current operational needs from a subscale proof-of-principle into a full-scale prototype for warfighter experimentation during laboratory and operational demonstrations, Fleet Battle Experiments (FBEs), Limited Objective Experiments (LOEs) and sea trial exercises.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: NAVAL WARFARE EXPERIMENTATION	18.731	20.602	20.608	0.000	20.608
Description: The objective of this project is to capitalize on recent technology breakthroughs to develop and integrate components including subsystems into prototypes quickly. These technologies are provided to the warfighter for experimentation, field experiments, and/or tests in simulated or actual environments. The use of Navy Warfare Development Command (NWDC) Fleet Experimentation (FLEX) events is encouraged and the net results are to gain the knowledge that only an experiment can provide. ***FY 2019 Plans:*** Continue efforts from FY18 that were in progress within PE 0603758N Navy Warfare Experimentation and initiate new efforts to address the priorities of the Chief of Naval Research and the Chief of Naval Operations. Efforts will be conducted within areas such as Augmented Warfighter, Integrated & Distributed Forces, Operational Endurance, Sensing & Sense-Making, and Scalable Lethality. ***FY 2020 Base Plans:*** Expand operational experimentation efforts through the creation and maintenance of an Experimentation and Analysis Opportunities catalog for use by the Naval Research Enterprise (NRE) in order to develop a prioritized list of concept investigations that will result in operational experimentation in the form of tests, demonstrations, and large and small scale experimentation that will address emerging operational needs. Early Technology Readiness Level concept investigations with Fleet and Force input will be conducted to establish concept					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603758N / *Navy Warfighting Exp & Demo*	**Project (Number/Name)** 2918 / *Navy Warfighting Experiments and Demo*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
potential, and inform NRE investment decisions. Additionally, experimentation will be used as an excursion to address additional warfighter needs or mitigate capability delivery risk. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020					
Title: OPERATIONS ANALYSIS ***Description:*** The objective of this project is to provide operational analysis through studies, analyses, gaming and experimentation to identify Navy and Marine Corps capability needs that can be addressed with S&T solutions. The effort includes core analysis of S&T programs, military utility/capability gaps analyses, war gaming, structured experimentation events, the articulation of the results of that analysis and war gaming, and the development of innovation strategies and messages resulting from these analyses. ***FY 2019 Plans:*** Conduct war games, Technology Innovation Games and technology analysis efforts to inform ONR S&T initiatives in such areas as Augmented Warfighter, Integrated & Distributed Forces, Operational Endurance, Sensing & Sense-Making, and Scalable Lethality. ***FY 2020 Base Plans:*** Conduct warfighter workshops to discover new concepts and issues and identify new focus areas for S&T development guided by the warfighter. Additionally, conduct Concept of Employment Development to explore existing or new S&T into training or exercises to improve effectiveness. Also conduct Concept of Operations development to explore how operational objectives or capabilities can be met with existing or new S&T. Additionally, work with the Navy Warfare Development Command in order to conduct Technology Innovation Games that help inform Science and Technology program capabilities. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.	2.017	2.216	2.204	0.000	2.204
Title: SWAMPWORKS	21.541	22.383	22.430	0.000	22.430

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603758N / *Navy Warfighting Exp & Demo*	**Project (Number/Name)** 2918 / *Navy Warfighting Experiments and Demo*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Description: The objective of this portfolio is to explore and develop high-risk technologies and concepts that advance naval warfighters capabilities. Short studies can be performed to examine the maturity and potential efficacy of a proposed technology before making substantial investments. The program has substantial programmatic flexibility and is not limited to any set of technology areas. Ultimately, the goal is to provide a dramatic improvement for the warfighter. Some of these technologies may become part of a follow-on technology development, may end up in the hands of the warfighter for Fleet/Force experimentation, or may culminate in a significant Fleet/Force exercise that demonstrates capability that transitions into the Acquisition Program of Record (POR). ***FY 2019 Plans:*** Continue projects in response to the Chief of Naval Research and the Chief of Naval Operations priorities as well as technologies of interest for the Pacific Area of Responsibility (AOR). The SwampWorks portfolio explores high-risk, disruptive, and innovative technologies and concepts, and provides a venue to develop innovative technologies. All SwampWorks activities are targeted towards advancing the capabilities of naval warfighters. Because of the portfolio's high-risk nature. While the portfolio is open to a wide variety of technology areas, some focus is applied to areas such as initiatives in such areas as Augmented Warfighter, Integrated & Distributed Forces, Operational Endurance, Sensing & Sense-Making, and Scalable Lethality. The balance of the S&T projects that will start in FY19 will be identified during FY19 as the needs of the warfighters, for investments in this portfolio, evolve or change. ***FY 2020 Base Plans:*** The balance of the S&T projects that will start in FY20 will be identified during FY20 as the needs of the warfighters, for investments in this portfolio, evolve or change. SwampWorks projects will be based on input from Naval Research Enterprise stakeholders (including the Naval enterprises, the combatant commands, OPNAV and Headquarters Marine Corps) and will be designed to exploit breakthroughs in science and technology in order to deliver maximum warfighting benefit to our sailors and marines. SwampWorks projects will be aligned with shared priorities throughout the whole of RDT&E in order to quickly advance new capabilities from discovery to deployment across the warfighting domains. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:***					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603758N / *Navy Warfighting Exp & Demo*	**Project (Number/Name)** 2918 / *Navy Warfighting Experiments and Demo*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
There is no significant change from FY 2019 to FY 2020.					
Title: TECH SOLUTIONS	9.186	10.184	10.126	0.000	10.126
Description: TechSolutions develops rapid response Science and Technology (S&T) solutions to immediate Fleet/Force needs identified by individual warfighters at the deckplate level. Sailors, Marines and Science Advisors submit their issues throughout the year via the TechSolutions website, email, phone, or chain of command. Projects are initiated from such requests and are completed in approximately twelve months, concluding with a prototype demonstration. ***FY 2019 Plans:*** This program will conduct new S&T developments based on Fleet/Force interactions and expressed warfighter needs. The program will be readily available to support the mission of the fleet by responding to Sailors/Marines need for technology. Developments will be undertaken to deliver rapid response solutions so warfighters can achieve mission success and perform their duties better, faster, or easier by leveraging technology that has recently been developed or is emergent. Demonstrations will be conducted with warfighters at the conclusion of developments to assess the utility of the technology and understand what steps remain to achieve transition. ***FY 2020 Base Plans:*** This program will conduct new S&T developments based on Fleet/Force interactions and expressed warfighter needs. The program will be readily available to support the mission of the fleet by responding to Sailors/Marines need for technology. Developments will be undertaken to deliver rapid response solutions so warfighters can achieve mission success and perform their duties safer, more effectively and more efficiently by leveraging technology that has recently been developed or is emergent. Demonstrations will be conducted with warfighters at the conclusion of developments to assess the utility of the technology and understand what steps remain to achieve transition. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: PRECISION STRIKE TECHNOLOGY	12.392	10.500	12.371	0.000	12.371
Description: The efforts described in this Activity are based on investment directions as defined in the Naval S&T Strategic Plan approved by the Science & Technology Corporate Board of 20 January 2015. This strategy					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603758N / *Navy Warfighting Exp & Demo*	**Project (Number/Name)** 2918 / *Navy Warfighting Experiments and Demo*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
is based on needs and capabilities from Navy and Marine Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It provides the vision and key objectives for the essential science and technology efforts that will enable the continued supremacy of U.S. Naval forces in the 21st century. The Strategy focuses and aligns Naval S&T with Naval missions and future capability needs that address the complex challenges presented by both rising peer competitors and irregular/asymmetric warfare. ***FY 2019 Plans:*** Conduct kill-chain studies to identify and recommend engineering trades to enable weapon system interoperability and data fusion alternatives. These studies assess engineering feasibility of various kill-chain options and assess the capability provided. ***FY 2020 Base Plans:*** Efforts in this area support Naval Precision Strike Operations, providing the Navy capability to quickly locate, target, and strike critical targets. Ongoing efforts include conducting kill-chain studies to identify and recommend engineering trades to enable weapon system interoperability and data fusion alternatives. These studies assess engineering feasibility of various kill-chain options and assess the capability provided. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 to FY 2020 increase supports additional investment in research of weapon system interoperability and data fusion alternatives for naval precision strike capabilities.					
Accomplishments/Planned Programs Subtotals	63.867	65.885	67.739	0.000	67.739

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603758N / *Navy Warfighting Exp & Demo*	**Project (Number/Name)** 2918 / *Navy Warfighting Experiments and Demo*

E. Performance Metrics

Overall metric goals are to transition the 6.3 advanced technology projects into acquisition programs of record, demonstrate successful technologies to enable new operational concepts, and enable the production of technology products such as proofs of concept and manufacturing packages. The performance of the work funded in this PE is reviewed at several levels to ensure that the investment is relevant and productive. At the macroscopic level, the investment is coordinated with Navy Warfare Development Command and Commander, Fleet Forces Command to address the goals and objectives identified for sea trials and Limited Objective Experiments (LOEs). At the microscopic level, the work funded in this PE is reviewed periodically by the Program Manager to ensure the investment is meeting the goals defined for each project. This review includes feedback collected from the warfighter community on all sea trials and LOEs to support the Program Manager's assessment of the value and relevance of each investment. Furthermore, the entire program is reviewed yearly by the Chief of Naval Research.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603782N *I Mine and Expeditionary Warfare Advanced Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	14.826	39.672	13.335	-	13.335	1.948	1.987	2.027	2.068	Continuing	Continuing
2917: *Shallow Water MCM Demos*	0.000	14.826	13.172	13.335	-	13.335	1.948	1.987	2.027	2.068	Continuing	Continuing
9999: *Congressional Adds*	0.000	0.000	26.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	26.500

A. Mission Description and Budget Item Justification

The efforts described in this Program Element (PE) are based on investment directions as defined in the Naval S&T Strategic Plan approved by the S&T Corporate Board and investment directions as defined by Department of Defense (DoD) Directive 5160.62 "Single Manager Responsibility for Military Explosive Ordnance Disposal Technology and Training (EODT&T)" and approved by the DoD Explosive Ordnance Disposal (EOD) Program Board (Sep 2012). This strategy is based on needs and capabilities from Navy and Marine Corps guidance, input from the Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). The strategy is also based on the unique needs and capabilities identified by the Joint Requirements Oversight Council (JROC) and the DoD EOD Program Board. It provides the vision and key objectives for the essential science and technology efforts that will enable the continued supremacy of U.S. Naval and Joint EOD forces in the 21st century. The strategy focuses and aligns Naval S&T with Naval missions, DoD EOD S&T with Joint EOD missions and future capability needs that address the complex challenges presented by both rising peer competitors and irregular/asymmetric warfare.

This PE primarily develops and demonstrates prototype Mine Countermeasures (MCM), Expeditionary Warfare and Joint EOD system components that support capabilities enabling Naval and Joint EOD Forces to influence operations ashore. Adversarial nations have the capability to procure, stockpile and rapidly deploy all types of naval mines, including new generation mines having sophisticated performance characteristics, throughout the littorals. They also have the capability to develop or modify explosive devices such as mines and unexploded ordnance to construct Improvised Explosive Devices (IEDs) for the purpose of targeting Joint Forces. Real world operations have demonstrated the requirement to quickly counter the mine threat. Current operations have also demonstrated the requirement to quickly counter the threat from explosive hazards and IEDs during DoD operations. Advanced technologies must rapidly detect and neutralize all mine types, from deep water to the inland objective. Advanced technologies must enable Joint EOD forces to detect/locate, gain access, diagnose, render safe, neutralize, recover, exploit and dispose of a broad spectrum of explosive hazards including unexploded ordnance and IEDs. This program supports the advanced development and integration of sensors, processing, warheads, and delivery vehicles to demonstrate improved Naval Warfare capabilities. It supports the advanced development and integration of sensors and tools for standoff capabilities such as detection and location of IEDs (particularly in dismounted operations), dismounted diagnosis of buried munitions and other explosive hazards, precision render safe and neutralization of surface munitions and other explosive hazards, and enhanced access to IEDs. It supports the MCM-related FNC Enabling Capabilities (ECs). Within the Naval Transformation Roadmap, this investment will achieve one of three key transformational capabilities required by Sea Shield as well as technically enable the Ship To Objective Maneuver (STOM) key transformational capability within Sea Strike.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603782N *I Mine and Expeditionary Warfare Advanced Technology*

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	15.164	0.000	0.000	-	0.000
Current President's Budget	14.826	39.672	13.335	-	13.335
Total Adjustments	-0.338	39.672	13.335	-	13.335
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	39.672			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.339	0.000			
• Program Adjustments	0.000	0.000	13.335	-	13.335
• Rate/Misc Adjustments	0.001	0.000	0.000	-	0.000

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Sensor for Maritime Capabilities Demonstration*	0.000	23.500
Congressional Add: *Additive Manufacturing*	0.000	3.000
Congressional Add Subtotals for Project: 9999	0.000	26.500
Congressional Add Totals for all Projects	0.000	26.500

Change Summary Explanation

Program change reflects original PE structure being retained

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319 / 3					R-1 Program Element (Number/Name) PE 0603782N / *Mine and Expeditionary Warfare Advanced Technology*				Project (Number/Name) 2917 / *Shallow Water MCM Demos*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
2917: *Shallow Water MCM Demos*	0.000	14.826	13.172	13.335	-	13.335	1.948	1.987	2.027	2.068	Continuing	Continuing

A. Mission Description and Budget Item Justification

This Program Element (PE) develops and demonstrates prototype technology for Mine Countermeasures (MCM), US Naval sea mining, and Expeditionary Warfare and Joint EOD system components that support capabilities enabling Naval and Joint EOD Forces to influence operations ashore. Adversarial nations have the capability to procure, stockpile and rapidly deploy all types of naval mines, including new generation mines having sophisticated performance characteristics, throughout the littorals. They also have the capability to develop or modify explosive devices such as mines and unexploded ordnance to construct Improvised Explosive Devices (IEDs) for the purpose of targeting Joint Forces. Real world operations have demonstrated the requirement to quickly counter the mine threat. Current operations have also demonstrated the requirement to quickly counter the threat from explosive hazards and IEDs during DoD operations. Advanced technologies must rapidly detect and neutralize all mine types, from deep water to the inland objective. Advanced technologies must enable Joint EOD forces to detect/locate, gain access, diagnose, render safe, neutralize, recover, exploit and dispose of a broad spectrum of explosive hazards including unexploded ordnance and IEDs. This program supports the advanced development and integration of sensors, processing, warheads, and delivery vehicles to demonstrate improved Naval Warfare capabilities.

This PE supports the advanced development and integration of sensors and tools for standoff capabilities such as detection and location of IEDs (particularly in dismounted operations), dismounted diagnosis of buried munitions and other explosive hazards, precision render safe and neutralization of surface munitions and other explosive hazards, and enhanced access to IEDs. It supports advanced development for battlespace shaping weapons including advanced undersea weapons. It supports the MCM related FNC Enabling Capabilities (ECs). Within the Naval Transformation Roadmap, this investment will achieve one of three key transformational capabilities required by Sea Shield as well as technically enable the Ship To Objective Maneuver (STOM) key transformational capability within Sea Strike.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**
Title: Joint EOD Demos	1.819	1.984	1.946	0.000	1.946
Description: This activity focuses on developing and demonstrating technologies to support a standoff or remote capability for detection and location, diagnosis, render safe, neutralization and enhanced access. Efforts include: electromagnetic, electro-optical, and acoustic sensors and systems for detection of explosive threat components including explosives, device housings/containers, and triggering mechanisms, standoff identification and confirmation of trace explosives, fusion of multi-sensor input for high confidence detection and diagnosis of buried threats, highly dexterous manipulators and imitative controllers for lightweight, efficient (strength/ weight ratio) dual manipulator systems integrated onto EOD robots for enhanced access, enhanced robotic autonomy to support EOD missions, data compression and visualization techniques to support precise render					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603782N / *Mine and Expeditionary Warfare Advanced Technology*	**Project (Number/Name)** 2917 / *Shallow Water MCM Demos*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
safe and neutralization, and neutralization devices containing reactive materials to neutralize devices with low collateral damage. This S&T investment supports the Joint Requirements Oversight Council (JROC) and DoD EOD Program Board validated requirements for Joint EOD missions. This S&T investment provides critical S&T transitions to acquisition programs. This investment in Joint EOD S&T is reported annually to the DoD EOD Program Board. This S&T investment is documented in the DoD EOD Applied Research Program Plan which is reviewed and approved annually by the DoD EOD Program Board. ***FY 2019 Plans:*** Conduct advanced technology development and demonstration in electro-optic & acoustic technologies for buried mine detection, robotic manipulation for ordnance exploitation & neutralization, standoff detection and classification for ordnance, and identification of explosives. Efforts in this thrust include prototype and demonstration of laser interferometric sensor / systems for detection of buried objects, highly dexterous dual manipulator systems (manipulators, controllers) for EOD robots for precision render safe and neutralization missions, Resonance Raman (single or dual wavelength) detector for standoff detection, and excavation tools and techniques for precision recovery and diagnosis of buried objects. Initiate development and demonstration of technologies for low-observability underwater ordnance neutralization. ***FY 2020 Base Plans:*** Conduct advanced technology development and demonstration in electro-optic & acoustic technologies for buried mine detection, robotic manipulation for ordnance exploitation & neutralization, standoff detection and classification for ordnance, and identification of explosives. Efforts in this thrust include prototype and demonstration of laser interferometric sensor / systems for detection of buried objects, highly dexterous dual manipulator systems (manipulators, controllers) for EOD robots for precision render safe and neutralization missions, technologies for low-observable underwater ordnance neutralization and technologies for the inspection of underwater explosive threats. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** No significant change between FY 2019 and FY 2020					
Title: Mine Technology ***Description:*** This activity focuses on developing and demonstrating technology to support on-demand battlespace shaping through advanced undersea weapons. Efforts include command & control (C2), remote	13.007	11.188	11.389	0.000	11.389

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603782N / *Mine and Expeditionary Warfare Advanced Technology*	**Project (Number/Name)** 2917 / *Shallow Water MCM Demos*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
control, advanced sensing technologies, compatibility with unmanned delivery options, detection & classification, and targeting solutions. The program, Modular Undersea Effector System (MUSE), is a limited duration effort for advanced mining and responds to recent request for capability from the fleet. ***FY 2019 Plans:*** Conduct advanced technology development and demonstration in advanced mining concepts including remote control, advanced sensing, command and control (C2), and more discriminative targeting solutions. Efforts in this thrust include prototyping advanced sensors and sensor configuration technologies for improved discrimination as well as communications, command, and control technologies. Initiate prototyping and demonstration for next-generation target detection devices. Funding supports JEON PC-0012 Advanced Maritime Mining Capability. ***FY 2020 Base Plans:*** Conduct advanced technology development in advanced mining technologies for clandestine, flexible, and scalable minefield deployment, longevity, and endurance, to include remote control, advanced sensing for detection and classification, command & control (C2), and more discriminative targeting solutions. Efforts in this thrust include prototyping and demonstration of advanced sensors and sensor configuration technologies for improved discrimination as well as communications, command, and control technologies. Continue prototyping and demonstration for next-generation target detection devices and mine effects. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** No significant change between FY 2019 and FY 2020					
Accomplishments/Planned Programs Subtotals	14.826	13.172	13.335	0.000	13.335

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603782N / *Mine and Expeditionary Warfare Advanced Technology*	**Project (Number/Name)** 2917 / *Shallow Water MCM Demos*

E. Performance Metrics

The overall metrics of this advanced technology program are the development of technologies supporting the Mine and Expeditionary Warfare challenges of reducing the MCM tactical timeline from months to days and eliminating the need for Navy divers and manned equipment to enter minefields. Another important metric is the scheduled transition of 6.3 advanced technology projects from the FNCs program into Navy and Marine Corps acquisition programs at agreed upon Technology Readiness Levels. Technology-specific metrics include: Mine warfare data fusion capabilities yielding a 10%-25% reduction in time and risk to mine hunting activities; Mine hunting sensors - Probability of Detection = 95%, Probability of Identification of Proud Mines = 90%, Probability of Classification of Buried Mines = 80%; Unmanned Systems for MCM sized for inclusion in the Littoral Combat Ship Mine Warfare Mission Package; MCM sensors sized, packaged and capable of 12 hour missions with a search rate greater than .05 square nautical mines per hour; Mine sweeping: Modular magnetic and acoustic influence sweeping systems packaged for deployment from Unmanned Surface Vehicles; Minesweeping single sortie coverage > 9.4 square nautical miles at 20 nautical miles per hour during a 4 hour mission up to Sea State 3; Surface-laid mine and obstacle breaching capability > 90% in the Beach Zone (BZ) using unitary warheads, and > 80% in the Surf Zone (SZ).

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603782N / *Mine and Expeditionary Warfare Advanced Technology*	Project (Number/Name) 9999 / *Congressional Adds*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	0.000	26.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	26.500

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Sensor for Maritime Capabilities Demonstration ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Development of an airborne, multi-spectral sensor to demonstrate potential for long range detection, increased persistence, and ability to operate on different ISR platforms.	0.000	23.500
Congressional Add: Additive Manufacturing ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Development of new advanced manufacturing technologies, such as additive manufacturing, friction stir welding and surface processing, and laser thermal and mechanical surface treatments to improve performance, increase reliability, and reduce costs for small turbojet and turbofans engines.	0.000	3.000
Congressional Adds Subtotals	0.000	26.500

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other Projects.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603801N *I (U) Innovative Naval Prototypes (INP) Adv Tech Dev*							
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	246.609	202.394	133.303	-	133.303	141.948	134.163	126.888	126.696	Continuing	Continuing
2480: *SSL-TM*	0.000	0.000	0.000	8.000	-	8.000	0.000	0.000	0.000	0.000	0.000	8.000
2481: *EMRG*	0.000	0.000	0.000	7.368	-	7.368	9.500	0.000	0.000	0.000	0.000	16.868
2958: *Cyberspace Activities*	0.000	0.000	0.000	14.498	-	14.498	16.489	15.939	0.000	0.000	0.000	46.926
3400: *Innovative Naval Prototypes (INP) Adv Tech Dev*	0.000	203.926	161.394	103.437	-	103.437	115.959	118.224	126.888	126.696	Continuing	Continuing
9999: *Congressional Adds*	0.000	42.683	41.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	83.683

Note

In FY 2020, three new stand alone project units were created for three INP major focus areas to better consolidate and coordinate the acceleration of these efforts. The three project units are: 2480 Solid State Laser Technology Maturation (SSL TM), 2481 the Electro-Magnetic Railgun, and 2958 Cyberspace Activities.

In FY 2020 a stand alone Artificial Intelligence (AI) R-2 Activity was established in Project Unit 3400 to consolidate and coordinate the acceleration of AI investments.

A. Mission Description and Budget Item Justification

The efforts described in this Program Element (PE) address the Advanced Technology Development associated with the Innovative Naval Prototypes (INP) Program. These investments represent game changing technologies with the potential to revolutionize operational concepts. They are disruptive in nature as they would dramatically change the way naval forces fight. INPs push the imagination of our nation's technical talent to deliver transformational warfighting capabilities.

The projects in this portfolio are high risk, technically challenging development efforts that offer the potential of high warfighting payoff in the future. The goal of these investments is to develop and demonstrate the viability of new technological capabilities via experimental prototypes that prove the new capability could be implemented if an acquisition program were to be modified or established to support further development. These technology investments are selected by a process that involves senior leadership in the Department of the Navy.

Developing INPs requires the development of subsystems and components, and efforts to integrate these subsystems and components into system prototypes for field experiments and tests in an appropriate environment. The efforts funded within this Program Element (PE) include concept and technology demonstrations of components and subsystems, which may be form, fit and function prototypes or scaled models that serve the same demonstration purpose. The goal of these development efforts is to prove the technological feasibility and assessment of subsystem and component operability and producibility rather than the development of hardware for service use. By demonstrating the general military utility and direct relevance to identified military needs, the technology becomes available for transition and further development within an emerging or new Program of Record. INP investments do not necessarily lead to subsequent development or procurement phases, but they do have the goal of moving out of Science and Technology (S&T) and into the acquisition process within the Future Years Defense Program (FYDP).

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603801N *I (U) Innovative Naval Prototypes (INP) Adv Tech Dev*

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE. Because to the nature of these projects described, technology development plans have been written with limited details due to information security concerns. Specific information on each project will be provided separately to the Congressional oversight committees.

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	108.285	161.859	86.898	-	86.898
Current President's Budget	246.609	202.394	133.303	-	133.303
Total Adjustments	138.324	40.535	46.405	-	46.405
• Congressional General Reductions	-	-0.465			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	41.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	99.195	0.000			
• SBIR/STTR Transfer	-4.917	0.000			
• Program Adjustments	0.000	0.000	45.941	-	45.941
• Rate/Misc Adjustments	0.000	0.000	0.464	-	0.464
• Congressional General Reductions Adjustments	-0.154	-	-	-	-
• Congressional Add Adjustments	44.200	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Program Increase*	23.176	0.000
Congressional Add: *Solid State Laser Technology Maturation*	7.919	0.000
Congressional Add: *Ruggedized High Energy Laser*	11.588	0.000
Congressional Add: *Electromagnetic Railgun*	0.000	10.000
Congressional Add: *Railgun with Hypervelocity Projectile*	0.000	31.000
Congressional Add Subtotals for Project: 9999	42.683	41.000
Congressional Add Totals for all Projects	42.683	41.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603801N *I (U) Innovative Naval Prototypes (INP) Adv Tech Dev*

Change Summary Explanation

Program changes for the FY 2020 President's Budget (PB) as compared to the FY 2019 PB 2020 baseline includes funds programmed for the HELCAP High Energy Laser Counter Anti-Ship Cruise Missile (ASCM) program. Additionally, in compliance with the Defense Planning Guidance (DPG) to increase Science and Technology funding to minimum levels, funding is programmed for ELEKTRA Non-Kinetic and EMW Capability; MINERVA - Air Enhanced Warfighter Decision Superiority Capability; Super Swarm; Advanced Long Range Targeting (ALRT); and additional funding for the High-power Joint Electromagnetic Non-Kinetic Strike (HIJENKS) programs.

Schedule: Not applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	Project (Number/Name) 2480 / *SSL-TM*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
2480: *SSL-TM*	0.000	0.000	0.000	8.000	-	8.000	0.000	0.000	0.000	0.000	0.000	8.000

Note

Solid State Laser Technology Maturation (SSL TM) plans and associated resources are realigned from Project 3400 in PE 0603801N into this new Project 2480 within PE 0603801N effective FY 2020.

A. Mission Description and Budget Item Justification

Solid State Laser Technology Maturation (SSL TM) is a multi-year effort in various stages of research and development within with the Navy's Innovative Naval Prototypes (INP) family of RDT&E programs. SSL-TM will develop a maritime laser weapons system prototype and test it on a representative test platform for a naval surface combatant, and conduct the required laser weapon system engineering, design, integration and testing necessary to have a testable, experimental prototype. This system will be capable of supporting missions such as defense against small boat and Unmanned Aerial Vehicle (UAV) swarms and Intelligence, Surveillance and Reconnaissance (ISR) disruption and defeat. At-sea testing will be conducted on the full laser weapon system demonstrator (i.e., prototype) from a representative test platform for a naval surface combatant.

Innovative Naval Prototypes (INP) and LA-Tech investments are typically 4-8 years in duration. They provide a continuance of basic research by maturing Innovative Naval Prototype technologies from a Technology Readiness Level
(TRL) of 2 or 3 to a TRL of 6. It is intended that prototypes developed within the INP portfolio, requiring both Budget Activity (BA) 2 and BA3 funding, are demonstrated in a relevant environment to prove the feasibility of the new
technological capability. Successful experimentations and demonstrations are intended to present the Department of the Navy with a programmatic challenge as these new capabilities can lead to the obsolescence of existing capabilities and significant decisions as to the path forward for integrating the new technological capabilities into the warfighting systems of the future. Project 2480 SSL-TM contains the resources and associated program justification for the Directed Energy/Electric Weapons capability oriented Solid State Laser Technology Maturation (SSL TM) INP program.

Because to the nature of these efforts and research activities, technology development plans have been written with limited details due to information security concerns. Specific information on each project and activity will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: Solid State Laser Technology Maturation (SSL TM)	0.000	0.000	8.000	0.000	8.000
Description: SSL-TM is a multi-year effort to develop a maritime laser weapons system prototype and test it on a representative test platform for a naval surface combatant, and conduct the required laser weapon system engineering, design, integration and testing necessary to have a testable, experimental prototype. This system will be capable of supporting missions such as defense against small boat and Unmanned Aerial Vehicle (UAV)					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	**Project (Number/Name)** 2480 / *SSL-TM*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
swarms and Intelligence, Surveillance and Reconnaissance (ISR) disruption and defeat. At-sea testing will be conducted on the full laser weapon system demonstrator (i.e., prototype) from a representative test platform for a naval surface combatant. ***FY 2019 Plans:*** N/A ***FY 2020 Base Plans:*** At-sea testing and experimentation will be conducted with full laser weapon system demonstrator (i.e. prototype) on an active duty navy surface combat ship. During this period the technical performance will be evaluated in various atmospheric and sea state conductions while conducting operational missions and exercises. Lessons learned from operations and maintenance will be documented to inform development of future laser weapons systems development efforts. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY19-FY20 Solid State Laser Technology Maturation (SSL TM) plans and associated resources are realigned from Project 3400 in PE 0603801N into this new Project 2480 within PE 0603801N effective FY 2020. Increase funding was provided in FY20 to further testing and experimentation in order to complete the S&T development and transition as planned.					
Accomplishments/Planned Programs Subtotals	0.000	0.000	8.000	0.000	8.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

In all cases, the technologies being developed within this PE support the Department of the Navy (DON) INP Program and are managed at the Office of Naval Research (ONR). The primary technological metrics used in this PE involve experiments and tests that demonstrate proof of concept for the technological capability being

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	**Project (Number/Name)** 2480 / *SSL-TM*

developed. Technology development is informed by periodic interaction with Naval warfighters, resource sponsors and the acquisition community. At the lowest level, each project is evaluated against technical and financial milestones on a frequent basis. Annually, each project is reviewed in depth for technical performance and development status by the Chief of Naval Research (CNR). DON leadership is briefed on the portfolio's status by the CNR.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	Project (Number/Name) 2481 / *EMRG*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
2481: *EMRG*	0.000	0.000	0.000	7.368	-	7.368	9.500	0.000	0.000	0.000	0.000	16.868

Note

Electro-Magnetic Railgun (EMRG) plans and associated resources are realigned from Project Unit 3400 in PE 0603801N into this new Project Unit 2481 effective FY 2020.

A. Mission Description and Budget Item Justification

Electro-Magnetic Railgun (EMRG) is a high-power, kinetic energy weapon capable of launching precision guided projectiles using electricity instead of chemical propellants. This multi-year effort will build a Railgun Weapon System (RGWS) by designing, fabricating and integrating Electromagnetic Railgun (EMRG) subsystems and components into a weapon system that brings new capabilities, increased capacity and improved operational economy to fleet operations at sea. With its increased velocity and extended range, the EM Railgun provides multi-mission potential for hypersonic missile defense, anti-air & surface warfare, and naval surface fire support.

EMRG is a multi-year effort in various stages of research and development within with the Navy's Innovative Naval Prototypes (INP) family of RDT&E programs. INP investments are typically 4-8 years in duration. They provide a continuance of basic research by maturing technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. It is intended that prototypes developed within this program, requiring both Budget Activity 2 (BA2) and Budget Activity 3 (BA3) funding, are demonstrated in a relevant environment to prove the feasibility of the new technological capability. Successful experiments and demonstrations are intended to present the Department of the Navy with a programmatic challenge as these new capabilities can lead to the obsolescence of existing capabilities, requiring significant decisions as to the path forward for integrating the new technological capabilities into the warfighting systems of the future. The Activity identified in Project Unit 2481 specifically addresses Advanced Technology Development in support of the Electro-Magnetic Railgun (EMRG) high-power, kinetic energy weapon prototype development INP effort.

Due to the nature of these projects, technology development plans have been written with limited details due to information security concerns. Specific information on each project will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: Electro-Magnetic Railgun (EMRG)	0.000	0.000	7.368	0.000	7.368
Description: The Electro-Magnetic Railgun (EMRG) is a high-power, kinetic energy weapon capable of launching precision guided projectiles using electricity instead of chemical propellants. This multi-year effort will build a Railgun Weapon System (RGWS) by designing, fabricating and integrating Electromagnetic Railgun (EMRG) subsystems and components into a weapon system that brings new capabilities, increased capacity and improved operational economy to fleet operations at sea. With its increased velocity and extended range,					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	**Project (Number/Name)** 2481 / *EMRG*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
the EM Railgun provides multi-mission potential for hypersonic missile defense, anti-air & surface warfare, and naval surface fire support. ***FY 2019 Plans:*** N/A ***FY 2020 Base Plans:*** Design, fabricate and integrate Electro Magnetic (EM) railgun subsystems and components into a system prototype including fully trainable, elevatable mount capable of rep-rate operations. Continue developing and testing prototype rep-rate railgun launcher that is suitable for installation in a prototype railgun gun mount. Conduct system level assessments of a Railgun Weapon System that is capable of closing the fire control loop. Demonstrate integration and use of Hyper Velocity Projectile (HVP) in a fixed elevation Railgun located at White Sands Missile Range. Conduct preliminary prototype system tests and demonstrations to prove the technological feasibility of the EMRG capability and assess sub-system and component operability under stressing rep-rate conditions. Develop next generation pulsed power (NGPP) system performance specifications for shipboard applications. Perform full-scale testing of long-life railgun launcher material solutions inserted in laboratory launchers. Design, build, test, and evaluate iterative electromagnetic railgun composite launcher prototypes to demonstrate the technological feasibility, performance, multi-shot life, and suitable firing rate of the system. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The increase in FY 2020 is due to the realignment of the Electro-Magnetic Railgun (EMRG) effort from Project Unit 3400 in PE 0603801N into this new Project Unit 2481.					
Accomplishments/Planned Programs Subtotals	0.000	0.000	7.368	0.000	7.368

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	**Project (Number/Name)** 2481 / *EMRG*

E. Performance Metrics

In all cases, the technologies being developed within this PE support the Department of the Navy (DON) INP Program and are managed at the Office of Naval Research (ONR). The primary technological metrics used in this PE involve experiments and tests that demonstrate proof of concept for the technological capability being developed. Technology development is informed by periodic interaction with Naval warfighters, resource sponsors and the acquisition community. At the lowest level, each project is evaluated against technical and financial milestones on a frequent basis. Annually, each project is reviewed in depth for technical performance and development status by the Chief of Naval Research (CNR). DON leadership is briefed on the portfolio's status by the CNR.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	Project (Number/Name) 2958 / *Cyberspace Activities*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
2958: *Cyberspace Activities*	0.000	0.000	0.000	14.498	-	14.498	16.489	15.939	0.000	0.000	0.000	46.926

Note

Project 2958 was established separately in this PE beginning in FY 2020 to better isolate and identify Innovative Naval Prototype (INP) efforts addressing Cyberspace INP advanced technology development.

A. Mission Description and Budget Item Justification

This Project contains all Advanced Technology Development Innovative Naval Prototype (INP) investments that are developing new technologies for cyber warfare. Potential adversaries are investing in advanced technologies that will challenge our advantages in the critical information domain. Nation states and non-state actors seek to degrade our command and control capabilities, networks and computer systems. Cyber threats continue to grow and rapidly proliferate. Technologies developed in this R2 Activity will enable the warfighter to take immediate, appropriate action at any time against any desired adversary, target or network by assuring that autonomous, continuous analyses of intelligence, persistent surveillance and open information sources have, at all times, optimized the possible courses of action based on commander's guidance. Technologies within this activity will foster operational endurance and enable sustained operations and resiliency for warfighters and platforms through enhanced cyber security/protection.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: Cyber	0.000	0.000	14.498	0.000	14.498
Description: This R2 Activity contains all Advanced Technology Development Innovative Naval Prototype (INP) investments that are developing new technologies for cyber warfare. Potential adversaries are investing in advanced technologies that will challenge our advantages in the critical information domain. Nation states and non-state actors seek to degrade our command and control capabilities, networks and computer systems. Cyber threats continue to grow and rapidly proliferate. Technologies developed in this R2 Activity will enable the warfighter to take immediate, appropriate action at any time against any desired adversary, target or network by assuring that autonomous, continuous analyses of intelligence, persistent surveillance and open information sources have, at all times, optimized the possible courses of action based on commander's guidance. Technologies within this activity will foster operational endurance and enable sustained operations and resiliency for warfighters and platforms through enhanced cyber security/protection.					
FY 2019 Plans: N/A					
FY 2020 Base Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	**Project (Number/Name)** 2958 / *Cyberspace Activities*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Conduct Advanced Technology Development of tools and techniques to achieve an automated, systematic reduction of any computing system's attack surface across all its layers of computing. Continue development and demonstration of tools and techniques enabling powerful tailoring of an end-system computing environment to match the needs of deployed applications and users, removing software bloat and unused features, resulting in significantly reduced cyber attack surface for both known and unknown vulnerabilities. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The effort was moved from the Cyber R-2 Activity in Project 3400 Innovative Naval Prototypes(INP) Advanced Technology Development and placed into this separate Project 2958 for FY20. The $1.8 million increase from the FY19 Cyber R-2 Activity ($12.656 million) in Project 3400 to $14.498 million here in FY20 is due to Advanced Technology Development associated with the planned third phase of the TPCP project, which covers efforts to develop tools and techniques for automatically customizing a range of standard communications protocols used in closed shipboard environments, tailoring end-system network stacks to match the needs of deployed applications. Addressing this computing layer is essential for achieving total protection of Navy cyber infrastructure and drastically reducing attack surface.					
Accomplishments/Planned Programs Subtotals	0.000	0.000	14.498	0.000	14.498

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

In all cases, the technologies being developed within this PE support the Department of the Navy (DON) INP Program and are managed at the Office of Naval Research (ONR). The primary technological metrics used in this PE involve experiments and tests that demonstrate proof of concept for the technological capability being developed. Technology development is informed by periodic interaction with Naval warfighters, resource sponsors and the acquisition community. At the lowest level,

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	**Project (Number/Name)** 2958 / *Cyberspace Activities*

each project is evaluated against technical and financial milestones on a frequent basis. Annually, each project is reviewed in depth for technical performance and development status by the Chief of Naval Research (CNR). DON leadership is briefed on the portfolio's status by the CNR.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	Project (Number/Name) 3400 / *Innovative Naval Prototypes (INP) Adv Tech Dev*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
3400: *Innovative Naval Prototypes (INP) Adv Tech Dev*	0.000	203.926	161.394	103.437	-	103.437	115.959	118.224	126.888	126.696	Continuing	Continuing

Note

Beginning in FY 2020, the Applied Research Electro-Magnetic Railgun (EMRG) high-power, kinetic energy weapon prototype development effort was realigned from Project Unit 3400 to Project Unit 2481 within PE 0603801N.

A. Mission Description and Budget Item Justification

Innovative Naval Prototypes (INP) and LA-Tech investments are typically 4-8 years in duration. They provide a continuance of basic research by maturing technologies from a Technology Readiness Level (TRL) of 2 or 3 to a TRL of 6. It is intended that prototypes developed within this program, requiring both Budget Activity (BA) 2 and BA3 funding, are demonstrated in a relevant environment to prove the feasibility of the new technological capability. The portfolio is periodically refreshed through the selection of new INPs and LA-Tech investments as existing ones are completed. Successful experimentations and demonstrations are intended to present the Department of the Navy with a programmatic challenge as these new capabilities can lead to the obsolescence of existing capabilities and significant decisions as to the path forward for integrating the new technological capabilities into the warfighting systems of the future. INPs and LA-Tech investments have been collectively grouped into R2 Activities that include Unmanned and Autonomous Systems, Directed Energy/Electric Weapons, Electromagnetic Maneuver Warfare, Cyber and Undersea Warfare.

Because to the nature of these efforts and research activities, technology development plans have been written with limited details due to information security concerns. Specific information on each project will be provided separately to the Congressional oversight committees.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: Cyber	5.066	12.656	0.000	0.000	0.000
Description: This R2 Activity contains all Advanced Technology Development Innovative Naval Prototype (INP) investments that are developing new technologies for cyber warfare. Potential adversaries are investing in advanced technologies that will challenge our advantages in the critical information domain. Nation states and non-state actors seek to degrade our command and control capabilities, networks and computer systems. Cyber threats continue to grow and rapidly proliferate. Technologies developed in this R2 Activity will enable the warfighter to take immediate, appropriate action at any time against any desired adversary, target or network by assuring that autonomous, continuous analyses of intelligence, persistent surveillance and open information sources have, at all times, optimized the possible courses of action based on commander's					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	**Project (Number/Name)** 3400 / *Innovative Naval Prototypes (INP) Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
guidance. Technologies within this activity will foster operational endurance and enable sustained operations and resiliency for warfighters and platforms through enhanced cyber security/protection. ***FY 2019 Plans:*** Continue developing the Technology to support enhanced Fleet/Force cyber protection and mitigation. Continue the Advanced Technology Development effort to develop resilient cybersecurity tools that will enable our warfighting platforms to fight through current and future cyber intrusions. ***FY 2020 Base Plans:*** N/A ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY19 to FY20 decrease is due to the movement of this effort into Project 2958 Cyberspace Activities in this PE.					
Title: Directed Energy / Electric Weapons ***Description:*** This R-2 Activity contains all Advanced Technology Development Innovative Naval Prototype (INP) investments that are developing new technologies for directed energy and electric weapons. Future adversaries will seek to neutralize U.S. conventional advantages by capitalizing on asymmetric capabilities that incorporate mobility, range, speed and deception. Naval platforms will be on the front line of our national integrated defensive capabilities to defeat these emerging threats that are proliferating. At the same time, the fleet/force must be able to effectively strike targets with survivable, scalable and cost-effective weapons that have sufficient range, speed and accuracy to complete a variety of missions while reducing risk to our warfighters and without creating unnecessary collateral damage or loss of life. Technologies within this activity will provide scalable lethality through enabling multi-domain, integrated, scalable kinetic and non-kinetic systems for offensive of defensive purposes. ***FY 2019 Plans:*** Continue Advanced Technology Development and studies focused on marinizing an operational laser weapon system, expanded efforts supporting and conducting sea-based developmental testing, and research supporting future systems integration of surface ship laser weapons.	133.558	98.463	37.225	0.000	37.225

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	**Project (Number/Name)** 3400 / *Innovative Naval Prototypes (INP) Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Initiate Advanced Technology Development efforts to evaluate the potential performance of an alternative laser source for future Surface Navy Laser Weapons System increments. Continue conducting Advanced Technology Development addressing the unique technical challenges inherent in the construction, assembly and operation of a high-power, kinetic energy weapon prototype capable of launching long range projectiles repeatedly. Continue Advanced Technology Development efforts to develop a radio frequency effects payload (a joint USAF/ USN project) with scalable electromagnetic effects. ***FY 2020 Base Plans:*** Develop technology for High Energy Laser Counter Anti-Ship Cruise Missile (ASCM) Project (HELCAP) by conducting development, experimentation, and demonstration of critical technologies to defeat crossing Anti-Ship Cruise Missiles (ASCM). This Applied Technology Development effort will include the following activities: assess development requirements including ASCM lethality and engagement parametric analysis, atmospheric propagation characterization, and beam control; design and fabricate a beam control testbed; and perform laser/materiel component interaction testing. HELCAP activities being conducted with 6.3 funds in this PE are focused on the assessment, development, and experimentation associated with lethality, advanced beam control, and laser sources. Related HELCAP project plans in PE 0603925N Directed Energy and Electric Weapon System Project 2731 include technology integration to support automated laser weapon control in integrated detect to defeat demonstrations. Continue Advanced Technology Development efforts associated with a Radio Frequency (RF) effects payload (a joint USAF/USN project) that has scalable electromagnetic effects. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY19 to FY20 decrease is due to the completion in FY19 of BA3 development associated with the Ruggedized High Energy Laser (RHEL) Phase I project and the realignment of the Electro-Magnetic Railgun (EMRG) high-power, kinetic energy weapon prototype effort and the Solid State Laser Technology Maturation (SSL-TM) effort from this Project to Projects 2480 (SSL-TM) and 2481 (EMRG) in this same PE. While funds					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	**Project (Number/Name)** 3400 / *Innovative Naval Prototypes (INP) Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
decreased for the overall R-2 Activity, resources were provided to continue development of technology for High Energy Laser Counter Anti-Ship Cruise Missile (ASCM) Project (HELCAP), previously known as RHEL PH II, and increase funding for HIJENKS.					
Title: Electromagnetic Maneuver Warfare	16.286	16.046	18.666	0.000	18.666
Description: This R-2 Activity contains all 6.3 Innovative Naval Prototype (INP) investments that are developing new technologies for Electromagnetic Maneuver Warfare (EMW). The electromagnetic spectrum is a key operational maneuver space enabled by continuous, real-time awareness of all spectrum activity. This R-2 Activity supports spectrum dominance which included efforts that focus on communications, surveillance, Electronic Warfare (EW) and electronics to understand and shape the battle space. The ability to assure access to the full spectrum is essential for battle space awareness and threat surveillance/weapon sensor engagement. Technologies within this activity will provide for integrated and distributed forces capable of dynamic synchronized actions through interoperable forces by incorporation of autonomous/disaggregated systems to increase flexibility and reach within the electromagnetic spectrum. ***FY 2019 Plans:*** Continue Advanced Technology Development to develop technology which will enable a strike group to work cooperatively in the Electromagnetic Spectrum (EMS) to optimize Electronic Warfare (EW), Information Operations (IO), communications, and radar performance. ***FY 2020 Base Plans:*** Conduct Advanced Technology Development efforts, demonstrating continuous spectrum monitoring for real-time prioritization and use of the electro-magnetic spectrum for shipboard systems and information operations, electronic warfare, surface warfare, undersea warfare, and air warfare missions across the entire battlegroup in a contested environment. Conduct a final at-sea Flexible Distributed Array (FlexDAR) demonstration. Conducts develop efforts of Advanced Long Range Targeting which directly accelerates and reduces risks to multiple programs. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:***					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	**Project (Number/Name)** 3400 / *Innovative Naval Prototypes (INP) Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
The increase from FY19 to FY20 is due to increased investment to develop efforts of Advanced Long Range Targeting which directly accelerates and reduces risks to multiple programs.					
Title: Undersea Warfare	12.736	1.486	4.871	0.000	4.871
Description: This R-2 Activity contains all Advanced Technology Development Innovative Naval Prototype (INP) investments that are developing new technologies for Undersea Maneuver Warfare. This R-2 Activity explores development of technologies to achieve and maintain undersea dominance in the areas of ASW and mine warfare, and to improve environmental sensing capabilities which support the Undersea Warfare domain. Technologies within this activity will dramatically improve sensing and sense-making, provide integrated and distributed autonomy to forces, and provide scalable lethality through development of kinetic and non-kinetic effects payloads. ***FY 2019 Plans:*** Complete Advanced Technology Development efforts to develop next generation ASW capability. ***FY 2020 Base Plans:*** Initiate Advanced Technology Development advanced technology development efforts associated with a mobile sensing system that can be deployed anywhere in the Arctic via a sea ice-based buoy that enables the critical infrastructure necessary to support persistent sensing at a lower cost that via manned platforms. This Arctic Mobile Observing System (AMOS) will operate via a sea ice-based buoy that enables the critical infrastructure necessary to support persistent sensing at a lower cost and with less risk than deploying manned platforms in the Arctic. Activities include buoy node construction and testing, software development, vehicle acquisition, and Arctic-hardening of sensors and platforms. The project includes domain-specific engineering development, upgrading UUV platform designs for the Arctic environment, developing the power and communication buoy node for the Arctic domain, incorporating mature and maturing UUV sensing capabilities into vehicles and ensure suitability for Arctic operations. The project will also develop under-ice CONOPS for the autonomous UUV network, building on capabilities developed under previous efforts for vehicle autonomy, re-charging, sensing, communication, and Command, Control, Communication & Computers (C4I), and develop new capabilities for operating under sea ice. A key thrust will be to enable an under-ice acoustic navigation system for unmanned platforms, suitable for use in any GPS-denied operational area. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:***					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	**Project (Number/Name)** 3400 / *Innovative Naval Prototypes (INP) Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
The FY19 to FY20 increase is due to the initiation of Advanced Technology Development efforts for a mobile sensing system.					
Title: Unmanned and Autonomous Systems	36.280	32.743	26.729	0.000	26.729
Description: This R-2 Activity contains all Advanced Technology Development Innovative Naval Prototype (INP) investments that are developing new technologies for Unmanned and Autonomous Systems. Increased proliferation of inexpensive lethal threats targeting individual warfighters and high-value assets, combined with continued rapid advances in computing, power and energy, robotics, sensors and position guidance technologies, drives the requirement to augment expensive manned systems with less expensive, unmanned, fully autonomous systems that can operate in all domains. Technologies within this activity will provide integrated and distributed, autonomous and disaggregated systems to increase flexibility, reach, and heterogeneous swarms. ***FY 2019 Plans:*** Continue Advanced Technology Development of autonomous payloads for large and extra-large unmanned undersea vehicles. Continue Advanced Technology Development of autonomy algorithms, the command and control architecture needed for swarm control (a flying ad-hoc network), effects payloads and sensing modalities. Continue Advanced Technology Development and integration of autonomy systems and various mission area payloads onto unmanned surface vehicles. ***FY 2020 Base Plans:*** Conduct Advanced Technology Development efforts associated with: - the development of autonomous payloads for extra-large unmanned undersea vehicles and complete first CLAWS autonomy/payload demo; - a robust, scalable, flexible, multi-functional swarming unmanned UxS vehicle systems providing cross-domain capability, human-swarm interdependence/interaction that is employable from surface, sub-surface, airborne, and ground manned and unmanned systems;					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	**Project (Number/Name)** 3400 / *Innovative Naval Prototypes (INP) Adv Tech Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
- a long endurance, unmanned surface vehicle with medium displacement that can be autonomously controlled in high sea states with a demonstrated multi-mission/multi-payload capability, including support for the Sea Hunter 2 builder's trial. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY19 to FY20 decrease is due primarily to the planned ramp down of Advanced Technology Development efforts associated with autonomy systems and various mission area payloads being developed for unmanned surface vehicles.					
Title: Artificial Intelligence ***Description:*** This R-2 Activity contains aligned Advanced Technology Development Innovative Naval Prototype (INP) investments that are accelerating development and deployment of new technologies using Artificial Intelligence. These advanced technology development efforts, being conducted in collaboration with related Applied Research investments in Program Element (PE) 0602792N INP, will create Artificial Intelligence technology for predictive mission-focused analytics that autonomously gather, analyze, compile, interpret, and visualize a fused tactical & national all source data picture to improve decision making speeds and establish a distributed Artificial Intelligence capability that can function in a harsh and adversarial environment and is able to determine an optimal response and react in real-time. ***FY 2019 Plans:*** N/A ***FY 2020 Base Plans:*** In collaboration with the applied research supporting this same INP research, actions are being taken to rapidly mature the advanced technology development efforts required to demonstrate machine speed battle management tools to support continuous analysis and planning at the operational and tactical levels, enabling the dynamic synchronization of forces and actions across intelligence, surveillance and reconnaissance, and combat systems. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:***	0.000	0.000	15.946	0.000	15.946

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
The FY19 to FY20 increase is due to the initiation of this R-2 Activity for FY20. This project is being initiated in response to the National Defense Strategy guidance for modernization of advanced autonomous systems. It will enable a broad array of autonomous functions, such as machine-speed decision making in Electromagnetic Warfare and Spectrum Management operations, through improvements in artificial intelligence.					
Accomplishments/Planned Programs Subtotals	203.926	161.394	103.437	0.000	103.437

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

In all cases, the technologies being developed within this PE support the Department of the Navy (DON) INP Program and are managed at the Office of Naval Research (ONR). The primary technological metrics used in this PE involve experiments and tests that demonstrate proof of concept for the technological capability being developed. Technology development is informed by periodic interaction with Naval warfighters, resource sponsors and the acquisition community. At the lowest level, each project is evaluated against technical and financial milestones on a frequent basis. Annually, each project is reviewed in depth for technical performance and development status by the Chief of Naval Research (CNR). DON leadership is briefed on the portfolio's status by the CNR.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603801N / *(U) Innovative Naval Prototypes (INP) Adv Tech Dev*	Project (Number/Name) 9999 / *Congressional Adds*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	42.683	41.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	83.683

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Program Increase ***FY 2018 Accomplishments:*** Supports slip ring testing, installation and operation of a Railgun test site at White Sands Missile Range (WSMR), Hyper Velocity Projectile compatibility testing, and requirements work for an articulating Railgun Mount. Specifically, funds planning, installation, and testing, including procurement of slugs, of a single shot Railgun at WSMR. ***FY 2019 Plans:*** N/A	23.176	0.000
Congressional Add: Solid State Laser Technology Maturation ***FY 2018 Accomplishments:*** Development and integration of Laser Weapon Console, Hybrid Predictive Avoidance and Safety Subsystem, Energy Storage Module, and Thermal Storage Module with Tactical Laser Core Module; systems integration and test; planning and system modifications necessary for ship installation and sea testing. ***FY 2019 Plans:*** N/A	7.919	0.000
Congressional Add: Ruggedized High Energy Laser ***FY 2018 Accomplishments:*** Conducted long lead procurement for the beam director required to support integrated laser weapons system testing, mission analysis, lethality and defeat of anti-ship cruise missile threats. ***FY 2019 Plans:*** N/A	11.588	0.000
Congressional Add: Electromagnetic Railgun ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** These funds will advance development towards a tactical system with investment in the mount and Next Generation Pulsed Power (NGPP) required for shipboard operation. Funding will advance mount	0.000	10.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
development to meet specifications for future shipboard application and develop modular concepts for evaluation and shipboard qualification testing.		
Congressional Add: Railgun with Hypervelocity Projectile ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Funds will be used in the development of the tactical Railgun mount; development and testing Hypervelocity Projectile (HVP) components and all up rounds in a Railgun launch; and to support simulated operational scenarios to quantify the value of HVP fired from a Railgun.	0.000	31.000
Congressional Adds Subtotals	42.683	41.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other Projects.