Exhibit R-2, **RDT&E Budget Item Justification:** PB 2016 Office of the Secretary Of Defense | **Date:** February 2015

Appropriation/Budget Activity
0400: *Research, Development, Test & Evaluation, Defense-Wide* **/** BA 2: *Applied Research*

R-1 Program Element (Number/Name)
PE 0602234D8Z **/** *Lincoln Laboratory*

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
Total Program Element	67.081	40.469	47.807	51.026	-	51.026	51.369	50.473	56.881	57.690	Continuing	Continuing
P534: *Lincoln Laboratory*	56.925	31.859	37.792	42.078	-	42.078	41.929	44.786	50.297	51.018	Continuing	Continuing
P535: *Technical Intelligence*	6.950	8.284	10.015	8.948	-	8.948	9.440	5.687	6.584	6.672	Continuing	Continuing
P536: *Testbed for Comparative Analysis*	3.206	0.326	-	-	-	-	-	-	-	-	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Lincoln Laboratory (LL) research line program is an advanced technology research and development effort conducted through a cost reimbursable contract with the Massachusetts Institute of Technology (MIT). The LL Program funds innovations that directly lead to the development of new system concepts, technologies, components and materials in support of Lincoln Laboratory's missions in Advanced Electronics Technology, Communications Systems, Cyber Security and Information Sciences, Intelligence, Surveillance and Reconnaissance Systems and Technology, Tactical Systems, Space Control, and Air and Missile Defense. The Lincoln Laboratory Program supports these missions by conducting research and development in nine science and engineering disciplines:

- Advanced Devices, with emphasis on development of devices and subsystems utilizing microelectronic, photonic, biological, and chemical technologies to enable new approaches to Department of Defense (DoD) systems.
- Optical Systems and Technologies, including the development of focal plane arrays, integrated imagers, laser communications, imaging and spectroscopic detection systems.
- Radio Frequency (RF) Systems and Technologies, including the development of novel active and passive radio frequency (RF) sensors, development of electronic protection and electronics attack technologies, and system concepts and communication systems.
- Information, Computation, and Exploitation, which includes the development of novel architectures, tools, and techniques for the processing, fusion, interpretation, computation, and exploitation of multi-sensor, multi-intelligence data.
- Cyber Security, which includes the development of technologies and new techniques for the protection of systems against cyber attack and exploitation.
- Biomedical Sciences and Technology, which supports the development of technologies to aid the warfighter, to investigate relevant research in brain and cognitive sciences, to develop engineered biological systems, and to assess physical performance and injury recovery.
- Autonomous Systems, which includes the development of technologies with the objective of developing mobile, autonomous, robotic platforms, sensors and algorithms that support key capabilities needed for a wide range of defense applications.
- Quantum System Sciences, which develops basic technologies that support sensing, communication and computation using quantum information, focusing on the demonstration of scalable computation platforms, demonstration of quantum protected communications and magnetic field sensing using highly-compact, atomic-like defects in diamond.
- Novel and Engineered Materials, with emphasis on new materials for additive manufacturing and emerging nanoscale materials.

Supporting these and other priority technology and capability areas are work efforts entitled Technical Intelligence and Testbed for Comparative Analysis:

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- Technical Intelligence is working to develop a comprehensive understanding of technology emergence and advancement in a range of relevant scientific areas such as nanotechnology, directed energy, and propulsion. Some details are classified, but one focus area is working to establish a broad horizon scanning and technology forecasting capability through a collaborative effort by the Department of Defense (DoD) and the Intelligence Community. This effort will develop insight into our relative position in science and technology around the world over time, as well as determine potential impacts on DoD capability development and future threat environments.
- The Testbed for Comparative Analysis will enable the evaluation of quantitative, horizon scanning and technology forecasting techniques for discovering disruptive technologies that may impact the DoD. This effort will provide the DoD with objective ways to evaluate the accuracy of existing and future horizon scanning and technology forecasting efforts.

B. Program Change Summary ($ in Millions)	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**
Previous President's Budget	41.868	51.875	53.993	-	53.993
Current President's Budget	40.469	47.807	51.026	-	51.026
Total Adjustments	-1.399	-4.068	-2.967	-	-2.967
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-4.000			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.020	-			
• SBIR/STTR Transfer	-1.379	-			
• Realignment for Higher Priority Programs	-	-	-2.822	-	-2.822
• FFRDC SEC 8104	-	-0.068	-	-	-
• Economic Assumptions	-	-	-0.145	-	-0.145

Change Summary Explanation

Funding decreases were used to pay for higher priority DoD bills.

Exhibit R-2A, **RDT&E Project Justification:** PB 2016 Office of the Secretary Of Defense			**Date:** February 2015
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602234D8Z / *Lincoln Laboratory*	**Project (Number/Name)** P534 / *Lincoln Laboratory*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
P534: *Lincoln Laboratory*	56.925	31.859	37.792	42.078	-	42.078	41.929	44.786	50.297	51.018	Continuing	Continuing

A. Mission Description and Budget Item Justification

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- Information, Computation, and Exploitation, which includes the development of novel architectures, tools, and techniques for the processing, fusion, interpretation, computation, and exploitation of multi-sensor, multi-intelligence data.
- Cyber Security, which includes the development of technologies and new techniques for the protection of systems against cyber attack and exploitation.
- Biomedical Sciences and Technology, which supports the development of technologies to aid the warfighter, to investigate relevant research in brain and cognitive sciences, to develop engineered biological systems, and to assess physical performance and injury recovery.
- Autonomous Systems, which includes the development of technologies with the objective of developing mobile, autonomous, robotic platforms, sensors and algorithms that support key capabilities needed for a wide range of defense applications.
- Quantum System Sciences, which develops basic technologies that support sensing, communication and computation using quantum information, focusing on the demonstration of scalable computation platforms, demonstration of quantum protected communications and magnetic field sensing using highly-compact, atomic-like defects in diamond.
- Novel and Engineered Materials, with emphasis on new materials for additive manufacturing and emerging nanoscale materials.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Advanced Devices ***Description:*** This project develops materials, devices, and subsystems utilizing microelectronic, nanostructure, photonic, biological, and chemical technologies to enable new system approaches to Department of Defense (DoD) systems. ***FY 2014 Accomplishments:*** In FY 2014, LL fabricated the world's lowest power field-programmable gate array (FPGA) for applications that require only modest computing speed with stringent power constraints of tens of microwatts. Additionally, development began on two focal-	5.195	6.253	6.722

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2014**	**FY 2015**	**FY 2016**
plane array technologies that provide highly flexible processing and high-sensitivity detection at visible and long-wave infrared wavelengths. Integrated photonics were designed for several applications, including more capable and lower size/weight/cost free-space laser communications. ***FY 2015 Plans:*** The low-power FPGA work will be completed and transitioned into demonstrations. The first fabrication of new visible and long-wave infrared focal plane arrays will be completed and a third type of imager will be pursued, based on charge-coupled devices (CCDs) made in germanium for multi-megapixel, short-wave infrared imaging. The germanium CCD development will benefit from years of development of record-performance silicon CCDs at Lincoln Laboratory and will build on recent advances in germanium material, particularly in large wafer formats. Additionally, the integrated photonics efforts will continue with a focus on both laser communications and chemical sensing applications. Finally, two new efforts will include transistor development in diamond for high power, high frequency radar, electronic warfare and communication applications; and the development of new micro-fluidic actuators based on super-capacitor technology for robotics and biomedical applications. ***FY 2016 Plans:*** The development of focal plane arrays, integrated photonics, emerging electronic components and microfluidics will continue. In FY 2016, the array size and performance of the advanced focal plane arrays is expected to reach a level suitable for demonstrations of a number of new applications. In particular, the advanced visible imagers will enable large-format, low-light-level imaging from fast moving, unstable platforms and the long-wave infrared focal planes will support wide-area persistent surveillance at night using thermal imaging from small, low-cost platforms. Support for work in diamond is expected to expand to include diamond heat spreaders (to cool high-power gallium nitride electronics and high power laser diodes) and for quantum sensing.			
Title: Optical Systems and Technologies ***Description:*** This project develops focal planes, integrated imagers, laser communication technology, imaging and spectroscopic systems. ***FY 2014 Accomplishments:*** Coherent combining of optical fields for imaging and laser systems was a major focus area. In particular, Lincoln Laboratory developed interferometric techniques for high-resolution imaging of satellites in geosynchronous orbit from a ground station and for high-resolution imaging of the Earth from a spacecraft. The interferometric imager work includes the development of new algorithms and the development of methods to mechanically support the apertures, measure the atmospheric phase aberrations, and apply phase corrections to each aperture. Additionally, advances in coherent combining of lasers were extended, for the first time, to quantum cascade lasers operating in the mid-wave infrared, with applications to infrared countermeasures and active hyperspectral imaging. Third, new computational imaging architectures were developed that leverage the capabilities	5.460	6.900	7.399

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2014**	**FY 2015**	**FY 2016**
of specialized focal plane arrays as a means to further improve performance. Finally, a new effort was initiated to develop a coherent focal plane array, which will enable wide area imaging of motion and vibration. ***FY 2015 Plans:*** Several efforts, including the ground-based interferometric imaging and the coherent combining of mid- and long-wave infrared lasers, will perform key demonstrations to enable follow-on transition efforts. The space-based interferometric imaging and computational imaging projects will be performing more advanced laboratory experiments. Based on techniques developed for interferometric imaging, a new effort will begin exploring digital algorithms for coherently combing laser communication receivers. Additionally, an underwater laser communication system will be developed and will be tested at a Naval Undersea Warfare Center site. A modest-sized version of the coherent focal plane array will be fabricated and configured for testing as an advanced hyperspectral imager. Several small efforts will explore new approaches to remote magnetometry for submerged target detection and remote surface characterization. ***FY 2016 Plans:*** The space-based interferometric imaging and the undersea laser communication system development efforts will demonstrate key performance metrics that are relevant to future systems. The laboratory experiments related to the coherent focal plane array and the computational imaging systems will advance beyond initial demonstration and characterization to more application-focused experiments. Finally, as the limitations of the new remote magnetometry-based target detection and remote surface characterization are understood, more advanced laboratory experiments and demonstrations will be performed.			
Title: Radio Frequency (RF) Systems and Technologies ***Description:*** This project develops novel active and passive RF sensors, new RF communication techniques, technologies for electronic protection and electronic attack, and new system concepts. ***FY 2014 Accomplishments:*** In FY 2014, final development of a cubesat with an integrated microwave radiometer was completed and the satellite was launched on July 13, 2014. Based on this initial cubesat, future nano-satellite development efforts for weather sensing have successfully transitioned to externally sponsored programs. Methods for further extending the linearity of radio frequency receivers were investigated using a technique called time-varying quantization, which can remove nonlinearities in the analog-to-digital conversion step. Techniques to improve antennas by making them conformal and by making smaller antennas with wider bandwidths were also developed. Finally, techniques to use integrated photonics to improve the bandwidth of simultaneous transmit and receive (STAR) systems were explored. ***FY 2015 Plans:*** Final testing of the low-power, high-linearity integrated receiver chip will be performed early in FY 2015 and this technology is expected to be transitioned to the Navy and potentially to other sponsors. As this project concludes, two new radio frequency (RF) integrated circuit efforts will be initiated: the development of miniature RF circuits integrated on chips with photovoltaic cells and	2.987	3.209	3.639

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2014**	**FY 2015**	**FY 2016**
batteries in a very thin, flexible form factor; and gallium nitride on silicon technology will be advanced to enable large, high-power, low-cost/scalable RF arrays for radar, communication and electronic warfare applications. Efforts to develop RF photonics will focus on developing a low noise figure, broadband amplifier that can support both remote antenna installations and can serve as the front-end for the more complex, integrated-photonics-based processing approaches that have previously been investigated. This low-noise-figure amplifier will use recently developed advances in high-power diode lasers, high-speed modulators and high-power photodetectors. New technology to integrate simultaneous transmit and receive (STAR) capabilities at the element level in phased arrays will also be developed. Finally, a number of RF communication efforts will be aimed at enabling networking in contested environments, providing higher-security RF waveforms and using compressed sensing techniques to create more advanced, low-cost receiver capabilities. ***FY 2016 Plans:*** Advances in the new integrated circuit efforts will continue, including progress towards higher performance components, better thermal management for high-power applications and more advanced demonstrations. Several efforts including the element-level simultaneous transmit and receive technology and the low-noise-figure RF photonic amplifier will begin key laboratory demonstrations. Finally, research of communication technologies will continue, with the higher-security RF waveforms likely to be ready for transition.			
Title: Information, Computation, and Exploitation Sciences ***Description:*** This project seeks to develop novel architectures, tools, and techniques for the processing, fusion, interpretation, computation, and exploitation of multi-sensor, multi-intelligence data. ***FY 2014 Accomplishments:*** Lincoln Laboratory developed techniques for processing large data sets, which include new efforts to compute on masked data and optimized analysis of large cyber, social media, and biological data sets. These techniques continue to be adopted by the intelligence community and other organizations that need to perform complex analysis of large and rapidly expanding data sets. Graph analytics techniques and bounds for network discovery were developed. A new hardware development effort was initiated to demonstrate a scalable architecture specifically optimized for graph analytics. Additionally, new analytics were developed for applications including multi-intelligence fusion of uncooperatively collected audio and visual datasets, customizable pattern analytics, analysis of satellite imagery, and more efficient change detection in synthetic aperture radar collections. ***FY 2015 Plans:*** The ‘big data’ effort will continue to advance in several ways, including further development of techniques for computing on masked data, the addition of new security tools, the integration of social media analysis with denser data sets and the expansion of capabilities to process large sensor-derived data sets. The graph processing efforts will move from the design and simulation stage to prototyping and demonstration. Finally, new techniques that were previously developed as part of individual analysis tools will be more tightly integrated into efforts aimed at (1) providing adaptive and interactive analytic capabilities, (2)	4.556	5.684	6.336

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
instrumenting and measuring how humans interact with these tools, and (3) integrating together tools that simulate and optimize the performance of algorithms on different hardware platforms. ***FY 2016 Plans:*** Continued advances will be pursued in the area of big data with an emphasis on the fusion of multiple types of data and more secure processing of this information. Additionally, more advanced demonstrations of new graph analysis tools, algorithms and processing architectures will be performed with an emphasis on relevant applications such as cyber security and hidden network detection. Finally, improved techniques for optimizing the way that analysis tools work with human analysts will be developed and the underlying algorithms will be better designed to use the capabilities of specialized processing platforms.			
Title: Cyber Security ***Description:*** Cyber Security develops technologies and new techniques for the protection of systems against cyber attack and exploitation. ***FY 2014 Accomplishments:*** The FY 2014 efforts included better approaches to protect systems and better tools to understand cyber vulnerabilities and exploitation strategies. Most of the system protection work was focused on cloud computing systems, including better techniques for protecting information storage and sharing in commercial cloud systems, new functional encryption techniques, and a private cloud testbed that was used to develop new technologies for future DoD and US government dedicated cloud systems. Additionally, a smaller effort was aimed at developing more secure processors that only require the data and operating instructions to be decrypted for a short period of time, in a very limited part of the processor, to limit vulnerabilities. Efforts aimed at understanding cyber vulnerabilities and exploitation strategies included the development of tools aimed at both small and large-scale systems. At the device level, a portfolio of widely applicable tools were developed for low-level reverse engineering of software and hardware. At the system level, tools for obtaining situational awareness of cyber protections, vulnerabilities and the history of a network were developed and deployed, both on the MIT Lincoln Laboratory network and more recently to DoD computer networks. ***FY 2015 Plans:*** Most of the cyber protection and evaluation efforts will continue to be advanced with the addition of a few new efforts. Efforts to protect cloud computing systems will focus on further advancing the private cloud testbed for developing a DoD-relevant architecture and there will be some additional work on functional encryption techniques. Additionally, the secure processor effort will be expanded and will be aimed toward transitioning to an externally-funded program. On the vulnerability evaluation side, the well-developed reverse engineering tool set will be used to create a new tool for constructing large corpora of realistic vulnerabilities, which is presently an important limitation for research into software vulnerabilities. The network cyber situational	3.597	4.282	4.520

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
awareness tools will continue to be transitioned to external networks and, in its place, a new effort will develop methods for characterizing and emulating hardware vulnerabilities, starting with malicious circuits in computer processors. ***FY 2016 Plans:*** Efforts will continue to develop the new architecture for secure cloud computing and an operational secure cloud system will be demonstrated and tested. The research on functional encryption and secure processors will also move toward advanced demonstrations. Finally, the tools for generating and emulating both software and hardware vulnerabilities will be expanded. For example, the hardware vulnerability effort will move beyond just computer processors to exploring vulnerabilities in peripheral devices, such as network controllers.			
Title: Biomedical Sciences and Technology ***Description:*** The Biomedical Sciences and Technology aids the warfighter, especially within the brain and cognitive sciences domain, with engineered biological systems and physiological monitoring for performance enhancement and injury recovery. ***FY 2014 Accomplishments:*** In the area of brain and cognitive sciences, award-winning techniques were developed for detecting depression and neurological disorders from vocal biomarkers and models were developed to understand the link between cognitive state and speech production. In the synthetic biology area, tools and techniques were developed to engineer new genetic codes and a 100-plex microfluidic module was built to test genetic code design. Third, to better understand physical injury and performance, several approaches were pursued. These included the world's first demonstration of ultrasound excitation and measurement using remote optical techniques. Finally, a number of biomarkers and epigenomic markers were measured and combined with other data to get a more complete understanding of performance, health, and recovery from injury. One project explored these correlations in humans for studying cognitive readiness while another studied the epigenomic landscape in mice with musculoskeletal injuries. ***FY 2015 Plans:*** The brain and cognitive sciences projects are expanding with new projects in mapping the functional connectivity of the brain and developing a non-invasive brain-computer interface for cognitive assessment. Both of these efforts will build on continued advancements in understanding the brain basis for speech with neurological disorders in order to develop better rehabilitation and learning strategies. Based on the successful transition of some of the past synthetic biology efforts to external programs, a new effort in FY 2015 will be aimed at three-dimensional (3D) printing of a mouse colon model that will serve as an artificial environment to co-culture and study engineered microbes. Finally, the physical injury and performance focus area will continue to develop a more advanced opto-acoustic imaging system with the goal of transitioning this work to an external sponsor. This area will also continue to advance techniques for correlated measurements of cognitive performance in humans, while focusing more on DoD-relevant problems and the predictive capabilities of this approach. ***FY 2016 Plans:***	3.144	3.817	4.051

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
The three focus areas will continue to be pursued with the brain and cognitive science work focusing on the newer efforts to advance our understanding of the brain and developing methods for interfacing it with computers. Additionally, the new thrust in developing a mouse colon model to culture complex microbial communities will be used to evaluate the effectiveness and competitiveness of engineered microbes in these cultures. Finally, new approaches to predict and impact human performance and to improve recovery from physical injury will continue to be developed.			
Title: Autonomous Systems ***Description:*** Autonomous systems technologies with the objective of developing mobile, autonomous, robotic platforms, sensors and algorithms that support key capabilities needed for a wide range of defense applications. ***FY 2014 Accomplishments:*** Autonomous system hardware efforts were focused on developing a new optical sensor, primarily for autonomous airborne platforms, and on developing technologies for autonomous undersea operations. The optical sensor development leveraged past investments in photon-counting detector arrays, which are integrated with readout circuits that can perform real-time processing of data. A custom sensor that can aid in autonomous navigation using optical flow and structured optical illumination techniques has been designed and is being fabrication based on this technology. Additionally, undersea testing was performed to study new techniques for obstacle avoidance and close engagement with moving vessels. These undersea tests also included measurements of an undersea power source based on seawater reactions with doped aluminum, which was developed in FY 2013 and is now transitioning to a start-up company for commercialization. Finally, algorithms were developed to improve the extraction of salient information from data for real-time decision making in autonomous systems. ***FY 2015 Plans:*** The autonomous system hardware efforts will continue and will enter a demonstration phase of development. The fabrication of the optical sensor for autonomous airborne navigation will be completed and the chip will be characterized. New algorithms that leverage the capabilities of this sensor will be further developed and testing of the algorithms on the chip will begin. Additionally, the undersea autonomy effort will focus on the development of models and strategies for control and navigation, particularly in environments with moving vessels. Finally, higher level algorithms for autonomous systems will correlate global positioning system (GPS) data with visual data and use different machine learning algorithms to enable operations in uncertain scenarios. ***FY 2016 Plans:*** Development of the optical sensor for airborne platforms will be completed and the sensor will be integrated with an unmanned aerial vehicle (UAV) for more advanced testing. The autonomous underwater technology will continue to be developed and the algorithms for control and navigation will be tested. Finally, the development of autonomy algorithms will explore ways to place guarantees on behavior and to enable new performance capabilities.	2.328	2.339	2.964
Title: Quantum System Sciences	3.592	4.108	4.647

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2014**	**FY 2015**	**FY 2016**
Description: Quantum information sciences to develop basic technologies that support sensing, communication and computation using quantum information. Focus on demonstration of scalable computation platforms, and demonstration of quantum protected communications and magnetic field sensing using highly-compact atomic-like defects in diamond. ***FY 2014 Accomplishments:*** The quantum system sciences projects include two quantum computing modalities and efforts in both quantum communication and quantum sensing. The quantum computing modalities include superconducting qubits and trapped ions, with both of these efforts focusing on the most forward-looking technology developments in their fields. These developments include record coherence times using scalable, gate-based architectures for superconducting qubits and the development of integrated photonics for scalable arrays of trapped ion qubits. New FY 2014 externally-funded efforts now support important companion technology development in both of these quantum computing modalities. The FY 2014 quantum communication work included theoretical efforts to understand the cryptographic security of quantum protocols and experimental efforts to develop single-photon detectors and entangled / single photon generators that offer record speed and efficiency. Finally, ensembles of nitrogen vacancies (atomic-like defects) in diamond were operated in a new geometry based on total internal reflection within the diamond to achieve the highest magnetic field sensitivity yet demonstrated for a diamond-based magnetometer. All of these quantum sciences efforts are closely connected to work on MIT campus through collaborations that involve both the MIT faculty, who are world-experts in these fields, as well as their graduate students who work collaboratively in both locations. As part of this collaboration, a 40-kilometer-long dark fiber link was established between MIT campus and MIT Lincoln Laboratory to enable future quantum communication demonstrations. ***FY 2015 Plans:*** The same quantum modalities will continue to be pursued with an evolving focus for several of the projects. The superconducting qubit work will continue to advance the state-of-the-art for the superconducting qubits themselves, particularly for long-term, gate-based quantum computing architectures, to complement external programs that support the development of superconducting circuits, control, packaging and adiabatic quantum computing architectures. The trapped ion work will continue to support integrated photonics for more scalable systems and will develop gallium-nitrite-based waveguides and modulators suitable for the wide range of wavelengths necessary to address the ions, these broadband optical devices will also be suitable for classical applications, including undersea imaging and communications. The quantum communication work will move towards improving a new protocol for high-rate, quantum-protected communication that avoids the need for a separate, slow key exchange step. Finally, the diamond magnetometer work will move from single axis measurements to full vector measurements and will adapt protocols from other quantum modalities to further increase the sensitivity of the sensor. Efforts to connect with MIT campus will be further strengthened and quantum communication protocols will be implemented over the fiber link. ***FY 2016 Plans:***			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
In addition to continued advances in superconducting qubits, trapped ions, quantum-protected communication and quantum magnetometry, additional efforts will be made to advance quantum algorithms. As the basic technology components and the path to scalable quantum systems are demonstrated, additional work on algorithms for quantum computation and quantum communication will become increasingly important to define future system architectures.			
Title: Novel and Engineered Materials ***Description:*** This project develops nanoscale materials and new materials to support high-resolution, multi-material additive manufacturing ***FY 2014 Accomplishments:*** Lincoln Laboratory imbedded active elements into both optical and radio frequency meta-materials to produce electrically tuned filters. Additionally, graphene, a two-dimensional material, was combined with plasmonic structures to act as optical limiters for focal plane arrays. This work was successfully transitioned into a separate program for further development. Finally, a new effort was initiated to develop low-loss polymer and metal materials that can be used in high-resolution additive manufacturing to print 3D high-performance conductive and dielectric materials. ***FY 2015 Plans:*** The effort to develop conductive and dielectric materials for additive manufacturing will be expanded and techniques for printing these materials in 3D will be developed in collaboration with Harvard University. The properties of radio frequency devices that are printed using these materials will be characterized and the materials will be further optimized. Additionally, a new effort in atomically-thin materials will focus on characterizing transition metal dichalcogenide materials to investigate the potential for using these devices in electronic, photonic, and sensing devices. ***FY 2016 Plans:*** Both the additive manufacturing and atomically-thin materials efforts will increasingly focus on device fabrication and characterization. The atomically-thin materials effort will focus on demonstrating electronic and optoelectronic properties that cannot be achieved from conventional materials, such as those based on the unique spin properties of transition metal dichalcogenides. The additive manufacturing materials effort will focus on developing microwave components that are suitable for emerging high-frequency bands. These devices can incorporate features that are not possible using subtractive machining and other traditional fabrication techniques, in order to enable lower-cost, more compact and higher performance microwave and millimeter wave systems.	1.000	1.200	1.800
Accomplishments/Planned Programs Subtotals	31.859	37.792	42.078

C. Other Program Funding Summary ($ in Millions)

N/A

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C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

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Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602234D8Z / *Lincoln Laboratory*	Project (Number/Name) P535 / *Technical Intelligence*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
P535: *Technical Intelligence*	6.950	8.284	10.015	8.948	-	8.948	9.440	5.687	6.584	6.672	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Technical Intelligence Program provides global science and technology (S&T) awareness and context in order to assist Defense decision-makers for an uncertain future. The program uses intelligence-based and open-source information to characterize today's global S&T environment, exploiting novel technology watch and horizon scanning (TW/HS) tools, to identify nascent and disruptive technologies that will shape tomorrow's future. Another set of products is tailored technical assessments that identify the military relevance, research opportunities, and policy recommendations of emerging and disruptive technologies.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Technical Intelligence	8.284	10.015	8.948
Description: The Technical Intelligence Program provides global science and technology (S&T) awareness and context in order to assist Defense decision-makers for an uncertain future. The program uses intelligence-based and open-source information to characterize today's global S&T environment, exploiting novel technology watch and horizon scanning (TW/HS) tools, to identify nascent and disruptive technologies that will shape tomorrow's future. Another set of products is tailored technical assessments that identify the military relevance, research opportunities, and policy recommendations of emerging and disruptive technologies. ***FY 2014 Accomplishments:*** In FY 2014, the Technical Intelligence program focused on programs which supported the characterization of today's global S&T environment, exploitation of novel TW/HS tools to identify nascent and disruptive technologies that will shape tomorrow's future, and the development of tailored technical assessments that identify the military relevance, research opportunities, and policy recommendations of emerging and disruptive technologies. Specifically: • JASON Program: Led efforts to award the new JASON Program contract – First time in 25 years. In addition, sponsored two JASON studies on national security topics: Artic Over the Horizon Radar (OTHR) and Millimeter Wave (MMW) Frequencies. Additional information on this effort is at a higher classification level. • Morning Express Program: Sponsored the development of a countermeasure system to protect forces and infrastructure from attack. Additional information on this effort is at a higher classification level. • Theories of Emergence Program: Sponsored a collaborative academic research effort to address the scientific basis behind predicting and detecting emerging S&T. The goal of these basic research efforts was to develop quantitative, theory-based approaches that increase the accuracy and effectiveness of predictive intelligence over time. • Technical Assessment Program: Sponsored multiple technical assessment activities to include a collaborative Synthetic Biology Challenge and technical assessments (printed Electronics, Quantum Magnetometry, and Autonomy).			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Office of the Secretary Of Defense		Date: February 2015
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602234D8Z / *Lincoln Laboratory*	**Project (Number/Name)** P535 / *Technical Intelligence*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
• Open-Source Capability Development: Sponsored the development of a contemporary website based on the Office of the Assistant Secretary of Defense for Research and Engineering (OASD(R&E)) S&T News Bulletin, which showcased S&T news stories and academic publications. ***FY 2015 Plans:*** In FY 2015, the Technical Intelligence program continues to support efforts that characterize today's global S&T environment, exploit novel TW/HS tools to identify nascent and disruptive technologies that shape tomorrow's future, and develop tailored technical assessments that identify the military relevance, research opportunities, and policy recommendations of emerging and disruptive technologies. Specifically: • JASON Program: Office of Technical Intelligence (OTI) sponsors the JASON group to support focused technical assessments on defense relevant problems. The topic areas include: Defense against Hypersonics, Science-Based Explosive Design, and Impacts of Emerging Biological Capabilities. • Technology Watch and Horizon Scanning (TW/HS) Tool Exploitation: OTI sponsors efforts on exploiting data analysis and TW/HS tools, to identify existing and unrecognized patterns, to provide non-obvious relationships using open source information, and to develop a better understanding on how to incorporate private-sector data analysis regarding technology development, trends, and potentially disruptive developments. • Technical Assessment Program: OTI sponsors multiple technical assessment activities that include human-systems integration and interface, autonomy and technology forecasting. ***FY 2016 Plans:*** In FY 2016, the Technical Intelligence program will continue to support efforts that will characterize today's global S&T environment, exploit of novel TW/HS tools to identify nascent and disruptive technologies that will shape tomorrow's future, and develop tailored technical assessments that identify the military relevance, research opportunities, and policy recommendations of emerging and disruptive technologies. Specifically: • JASON Program: OTI will sponsor the JASON group to support focused technical assessments on defense relevant problems. The topic areas will include: advanced electronics, autonomy, electronic warfare and protection, energy and power technologies, engineered resilient systems, space, sensor and processing systems, and human systems. • Technology Watch and Horizon Scanning (TW/HS) Tool Exploitation: OTI will sponsor efforts on exploiting data analysis and TW/HS tools, to identify existing and unrecognized patterns, to provide non-obvious relationships using open source information. • Technical Assessment Program: OTI will sponsor multiple technical assessment activities that will support the community of interest topic areas, and may include cognitive neuroscience, optics and directed energy, and energy storage capture and storage.			
Accomplishments/Planned Programs Subtotals	8.284	10.015	8.948

Exhibit R-2A, RDT&E Project Justification: PB 2016 Office of the Secretary Of Defense		**Date:** February 2015
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602234D8Z / *Lincoln Laboratory*	**Project (Number/Name)** P535 / *Technical Intelligence*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Office of the Secretary Of Defense			**Date:** February 2015
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602234D8Z / *Lincoln Laboratory*	**Project (Number/Name)** P536 / *Testbed for Comparative Analysis*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
P536: *Testbed for Comparative Analysis*	3.206	0.326	-	-	-	-	-	-	-	-	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Testbed for Comparative Analysis program supports the Technical Watch and Horizon Scanning (TW/HS) efforts within the Office of Technical Intelligence (OTI). The TW/HS program identifies nascent and disruptive technologies that will shape the future science and technology (S&T) landscape through the exploitation of novel TW/HS tools. The Testbed for Comparative Analysis program provides OTI the ability to quantitatively and qualitatively test and evaluate techniques for technology forecasting and horizon scanning.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Testbed for Comparative Analysis ***Description:*** The Testbed for Comparative Analysis program supports the Technical Watch and Horizon Scanning (TW/HS) efforts within the Office of Technical Intelligence (OTI). The TW/HS program identifies nascent and disruptive technologies that will shape the future science and technology (S&T) landscape through the exploitation of novel TW/HS tools. The Testbed for Comparative Analysis program provides OTI the ability to quantitatively and qualitatively test and evaluate techniques for technology forecasting and horizon scanning. ***FY 2014 Accomplishments:*** In FY 2014, the Testbed for Comparative Analysis program supported efforts identifying nascent and disruptive technologies that shape the future science and technology (S&T) landscape through the exploitation of novel TW/HS tools. Specifically: • TW/HS Pilot System Development: Sponsored efforts to develop an autonomous TW/HS prototype operating system, which may provide early identification of emerging and developing technologies.	0.326	-	-
Accomplishments/Planned Programs Subtotals	0.326	-	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A