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Exhibit R-2, RDT&E Budget Item Justification: PB 2012 Defense Advanced Research Projects Agency **DATE:** February 2011

APPROPRIATION/BUDGET ACTIVITY				R-1 ITEM NOMENCLATURE							
0400: <i>Research, Development, Test & Evaluation, Defense-Wide</i> BA 2: <i>Applied Research</i>				PE 0602305E: <i>MACHINE INTELLIGENCE</i>							
COST (\$ in Millions)	FY 2010	FY 2011	FY 2012 Base	FY 2012 OCO	FY 2012 Total	FY 2013	FY 2014	FY 2015	FY 2016	Cost To Complete	Total Cost
Total Program Element	-	44.682	61.351	-	61.351	52.276	51.752	51.484	51.484	Continuing	Continuing
MCN-01: <i>MACHINE INTELLIGENCE</i>	-	44.682	61.351	-	61.351	52.276	51.752	51.484	51.484	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Machine Intelligence project is budgeted in the Applied Research Budget Activity because it is developing technologies that will enable computing systems to extract and encode information from dynamic and stored data, observations, and experience, and to derive new knowledge, answer questions, reach conclusions, and propose explanations. Enabling computing systems with machine intelligence in this manner is now of critical importance because sensor, information, and communication systems continuously generate and deliver data at rates beyond which humans can assimilate, understand, and act. Since its creation over 50 years ago, artificial intelligence (AI) has gone through several phases. Initially, AI emphasized rule-based and symbolic approaches. These were eventually reconceived using a human-intelligence paradigm ("cognitive computing"). Recently, a more powerful approach has emerged, with rule-based, symbolic and human-oriented approaches combined with large-scale statistical approaches that make explicit use of massive distributed data and information bases. These data/information bases are curated (e.g., machine-filtered or human-selected) and raw (e.g., as originally obtained and perhaps of unknown provenance); structured (e.g., tabular or relational) and unstructured (e.g., text documents, multi-media files); static (e.g., historical, unchanging) and dynamic (e.g., real-time sensor data). This explosion in available data/information, combined with the ready availability of inexpensive mass storage and ubiquitous, inexpensive, computation-on-demand, provide the foundation for entirely new machine intelligence capabilities. The technologies developed in the Machine Intelligence project will result in revolutionary capabilities in military command and control, intelligence, decision-making, and situational awareness/indications and warning for a complex, global environment where traditional (e.g., nation-states) and non-traditional (e.g., trans-national) actors and new classes of cyber-physical-human threats have become the status quo.

B. Program Change Summary (\$ in Millions)	FY 2010	FY 2011	FY 2012 Base	FY 2012 OCO	FY 2012 Total
Previous President's Budget	-	44.682	68.972	-	68.972
Current President's Budget	-	44.682	61.351	-	61.351
Total Adjustments	-	-	-7.621	-	-7.621
• Congressional General Reductions		-			
• Congressional Directed Reductions		-			
• Congressional Rescissions	-	-			
• Congressional Adds		-			
• Congressional Directed Transfers		-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• TotalOtherAdjustments	-	-	-7.621	-	-7.621

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Change Summary Explanation FY 2012: Decrease reflects minor repricing of on-going programs and Defense Efficiencies for contractor staff support.				
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2010	FY 2011	FY 2012
Title: Machine Reading and Reasoning Technology*		-	23.896	29.859
Description: *Previously funded in PE 0602304E, Project COG-02.				
The Machine Reading and Reasoning Technology program will develop enabling technologies to acquire, integrate, and use high performance reasoning strategies in knowledge-rich domains. Such technologies will provide DoD decision makers with rapid, relevant knowledge from a broad spectrum of sources that may be dynamic and/or inconsistent. To address the significant challenges of context, temporal information, complex belief structures, and uncertainty, new capabilities are needed to extract key information and metadata, and to exploit these via context-capable search and inference. Cognitive inference has traditionally emphasized deduction via theorem-proving and induction via statistical techniques, but abduction - also known as "inference to the best explanation"- is also likely to play a large role. Machine Reading addresses the prohibitive cost of handcrafting information by replacing the expert, and associated knowledge engineer, with un-supervised or self-supervised learning systems, systems that "read" natural text and insert it into artificial intelligence knowledge bases, i.e. data stores especially encoded to support subsequent machine reasoning. Machine Reading requires the integration of multiple technologies: natural language processing must be used to transform the text into candidate internal representations, and knowledge representation and reasoning techniques must be used to test this new information to determine how it is to be integrated into the system's evolving models so that it can be used for effective problem solving.				
FY 2011 Plans:				
- Extend knowledge extraction capabilities of machine reading systems to acquire simple relationship information in addition to factual data.				
- Force generality of machine reading systems through introduction of multiple, hidden domains.				
- Develop knowledge extraction, representation, and reasoning capabilities to support spatial, complex temporal, and event reasoning.				
FY 2012 Plans:				
- Develop capability to automatically learn reading patterns by addressing ambiguity resolution and discovering inference patterns.				
- Demonstrate temporal reasoning over facts and events extracted from text.				
- Begin developing military transition with DoD organization focused on semantic understanding of heterogeneous knowledge sources in a targeted domain.				

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C. Accomplishments/Planned Programs (\$ in Millions)		FY 2010	FY 2011	FY 2012
- Develop techniques for inferring potentially classified information from unclassified text.				
Title: Mind's Eye* Description: * Previously funded in PE 0602304E, Project COG-02. The Mind's Eye program is developing a machine-based capability that currently exists only in animals: "visual intelligence," the capability to learn generally applicable and generative representations of action between objects in a scene, directly from visual inputs, and then to reason over those learned representations. Mind's Eye will add the perceptual and cognitive underpinnings for reasoning about the action in scenes, enabling the creation of a more complete narrative for the visual field. The technologies developed under Mind's Eye will have broad applicability in robotics and surveillance. FY 2011 Plans: - Develop initial visual intelligence implementation and evaluate on relevant dataset(s). - Identify systems integration opportunities and perform initial systems engineering analysis. FY 2012 Plans: - Develop improved visual intelligence capabilities based on initial assessment(s) and evaluate on additional relevant dataset(s). - Integrate visual intelligence into a prototype smart camera and perform concept demonstration.		-	10.000	16.000
Title: Web-Scale Information Integration Description: The Web-Scale Information Integration program will create technologies to automatically integrate distributed information bases for broad strategic and tactical battlespace awareness, including technologies to automate the integration of multiple media (text, video, and digital photographs) as well as analyze, index, and store that media, so that it can be easily queried and retrieved by users across the DoD enterprise. A key enabler is the development of advanced document/content/information-object services including indexing, metadata creation, search, versioning, records management, schema alignment, and information visualization. Program interest extends to semantic web technologies whereby the semantics of information and services are made explicit, enabling machines to understand and satisfy the information requests of users (people and machines). This includes the technologies needed to automatically create and maintain, in real-time, encyclopedic knowledge of critical military, scientific, economic and social-cultural information in formats that are both human readable and machine processable. Such encyclopedic knowledge of the world will provide fundamental context to counter-insurgency, global strike and (near-) peer conflict including strategy, rules of engagement, planning and execution, while semantically-enabled search and processing will automate information discovery and manipulation to enable better decision-making for warfighters. FY 2011 Plans:		-	10.786	15.492

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C. Accomplishments/Planned Programs (\$ in Millions)		FY 2010	FY 2011	FY 2012
<ul style="list-style-type: none"> - Integrate dialogue system with semantically-enabled search capabilities to enable intelligent, user-defined Web search routines. - Link dialogue semantics with learning-by-demonstration techniques to produce reusable and composable Web search and content manipulation services. - Conceptualize approaches for authoring, maintaining, querying, and visualizing global knowledge capable of scaling to tens of millions of articles, inference over uncertain/inconsistent data, socially reconciling semantic inconsistencies, and additional social challenges (contrasting point of view, non-logical semantics, etc.). <p><i>FY 2012 Plans:</i></p> <ul style="list-style-type: none"> - Extend dialogue capability to enable user-defined extensions to descriptions of Web semantics. - Develop and demonstrate cognitive agents that greatly reduce the time it takes users to find and process information on the World Wide Web. - Develop approaches for extracting and representing facts and implications from crowd-sourced information streams as well as tracking provenance and detecting inconsistent data. - Identify operational scenarios (use cases), needs, and constraints. 				
Accomplishments/Planned Programs Subtotals		-	44.682	61.351
D. Other Program Funding Summary (\$ in Millions) N/A				
E. Acquisition Strategy N/A				
F. Performance Metrics Specific programmatic performance metrics are listed above in the program accomplishments and plans section.				

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