Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Office of the Secretary Of Defense	Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
Total Program Element	102.926	46.500	49.748	51.596	-	51.596	52.467	53.480	54.513	55.566	Continuing	Continuing
534: *Lincoln Laboratory*	85.021	38.126	44.275	41.359	-	41.359	42.224	43.141	44.053	44.974	Continuing	Continuing
535: *Technical Intelligence*	17.905	8.374	5.473	6.737	-	6.737	6.743	6.839	6.960	7.092	Continuing	Continuing
815: *Cyber Security, Science and Engineering*	-	0.000	0.000	3.500	-	3.500	3.500	3.500	3.500	3.500	Continuing	Continuing

Note

Service Requirements Review Board (SRRB) efficiencies are included.

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 supports innovative, multi-disciplined research that addresses critical national security problems. The LL Program funds innovations that directly lead to the development of new system concepts, technologies, components and materials in support of Department of Defense (DoD) missions. Funding supports high-risk, high-payoff research, which provides unique and specialized capabilities for the current and emerging needs of the DoD. The project funds ten technology project areas.

Of these, there are five core-technology areas:
- Advanced Devices
- Optical Systems and Technology
- Information, Computation and Exploitation
- Radio-Frequency (RF) Systems and Technology
- Cyber Security, Science and Engineering

There are four emerging-technology initiatives:
- Advanced Materials and Processes
- Quantum System Sciences
- Biomedical Sciences and Technology
- Autonomous Systems

There is one Integrated Systems technology area, which focuses on combining novel component-level technologies to create system-level technology solutions for important DoD problems.

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These ten technology areas provide critical capabilities that support all DoD mission areas pursued at the Laboratory. The categories are selected in consultation with the Office of the Under Secretary of Defense, Research and Engineering (OUSD(R&E)), are aligned with DoD Communities of Interest (CoI), and with guidance from other DoD agencies to address technology as well as system needs. The research in these categories adapts to solve emerging DoD problems as well as longstanding problems to which new technology advances can be applied. The individual projects in each area are selected with the goal of enhancing DoD capabilities significantly, rather than incrementally.

Supporting these and other priority technology and capability areas are work efforts titled Technical Intelligence:
• The Technical Intelligence Program provides global science and technology (S&T) awareness and context in order to assist the DoD decision-makers plan 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. The program complements this with tailored technical assessments that identify the military relevance, research opportunities, and policy recommendations for emerging and disruptive technologies.

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	48.269	49.748	55.971	-	55.971
Current President's Budget	46.500	49.748	51.596	-	51.596
Total Adjustments	-1.769	0.000	-4.375	-	-4.375
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.709	-			
• Other Program Adjustments	-0.007	-	-4.029	-	-4.029
• FFRDC Transfer	-0.053	-	-	-	-
• Economic Assumption	-	-	-0.346	-	-0.346

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: 815: *Cyber Security, Science and Engineering*		
Congressional Add: *N/A*	0.000	0.000
Congressional Add Subtotals for Project: 815	0.000	0.000
Congressional Add Totals for all Projects	0.000	0.000

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Change Summary Explanation

FY 2019 adjustments include realignment for higher priorities.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Office of the Secretary Of Defense											Date: February 2018	
Appropriation/Budget Activity 0400 / 2					R-1 Program Element (Number/Name) PE 0602234D8Z / *Lincoln Laboratory*				Project (Number/Name) 534 / *Lincoln Laboratory*			
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
534: *Lincoln Laboratory*	85.021	38.126	44.275	41.359	-	41.359	42.224	43.141	44.053	44.974	Continuing	Continuing

A. Mission Description and Budget Item Justification

The ten Lincoln Laboratory research areas that comprise the overall research and development portfolio are described below:

Five core-technology areas:

• Advanced Devices emphasizes the development of devices and subsystems utilizing microelectronic, photonic, biological, and chemical technologies to enable new approaches to DoD systems. Projects include technologies for high power RF devices; multi-function, highly integrated lasers; fast and sensitive imagers; and mechanical microsystems for autonomous systems.

• Optical Systems and Technology focuses on developing optical technologies for visible, infrared, and wide band spectroscopic sensing as well as communications systems. The projects areas include high energy lasers; scalable focal plane imaging technology; photonic integrated circuits; optical system prototypes; and associated phenomenology measurements.

• Information, Computation and Exploitation develops novel architectures, tools, and techniques for the processing, fusion, interpretation, computation, and exploitation of multi-sensor, multi-intelligence data. Projects include innovative hardware and software technologies for graph processors and cloud computing; artificial intelligence and graph algorithms for analytics, including deep learning algorithms; multi-intelligence analytics, including open-source data processing techniques; and human-machine interfacing and automation technologies to enhance warfighter effectiveness and ability to work with advanced computing systems.

• RF Systems and Technology focuses on RF technologies to enhance warfighting capabilities in radars, electronic warfare (EW), and communications. Projects include development of next generation phased arrays; ultra-wideband RF systems; compact RF systems; small satellite RF payload; and advanced algorithms for jammer mitigation and EW.

• Cyber Security Science and Engineering Program focuses on the development of technologies and new techniques for the protection of systems against cyber-attack and exploitation. Projects include research into technologies for cyber situational awareness, command and control; technology to improve resilience of systems to cyber-attack; and technologies for system exploitation research.

Four emerging-technology areas:

• Advanced Materials and Processes (formerly Novel and Engineered Materials) emphasizes research in new materials for additive manufacturing and emerging nanoscale materials. Projects include research in microwave circuits built with 3D printing; other advanced 3D printing technologies; one-dimensional semiconductor materials; and microsystems using metamaterials.

• Quantum System Sciences focuses on the development of quantum-based technologies that support sensing, communication, computation, and algorithms using quantum information. The projects include the demonstration of scalable computation platforms, demonstration of quantum protected communications and magnetic field sensing using highly-compact, atomic-like defects in diamond, prototyping revolutionary quantum networking systems and technology, and research into advanced quantum algorithms.

• Biomedical Sciences and Technology supports the development of bio-engineered and biomedical technologies to aid the warfighter. Projects include brain imaging technologies; relevant research in brain and cognitive sciences; engineered biological systems to aid physiology understanding; and technologies to assess physical performance and enhance injury recovery.

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• Autonomous Systems has the objective of developing mobile, autonomous, robotic platforms, as well as sensors and algorithms that support key capabilities needed for a wide range of DoD applications. Projects span advanced artificial intelligence and processing; sensors and communications for unmanned platforms; platform designs and energy systems; human-machine interactions; and verification and validation of autonomous systems.

One system technology area:
• Integrated Systems technology projects use multiple new technologies to solve important national problems. Projects selected for funding have an applied research component focused on integrated technology capability or technologies that facilitate greater levels of integrated capability. Projects target key DoD warfare domains, including space, air, land, sea surface, and undersea.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Advanced Devices	4.500	5.391	5.099
Description: This project area targets the research and development of unique and innovative components, subsystems, and sensing concepts or methodologies that enable new solutions to important DoD problems. Activities under this technology area include specialized silicon and compound semiconductor-based devices for RF, analog, mixed-signal, and digital electronics; photonics, optoelectronics and laser technologies; novel devices and concepts for chemical, biological, and radiation sensing; and micro-hydraulic devices for motors and actuation.			
FY 2018 Plans: More sensitive prototypes of larger format imagers integrated with small-pitch read-out integrated circuits (ROICs) will be developed. Subsystem demonstrations of photonic-integrated gyroscopes will measure the gyroscope accuracy and reliability. Prototype circuits of a new class of high-power, diamond-based wideband transistors will help evaluate the promise of this technology. Gallium nitride (Ga N)-based photonic components operating at blue-green wavelengths will be matured and demonstrated in system prototypes. Projects for FY 2018 include developing higher performing substrates for infrared devices; developing pixel arrays that integrate germanium detectors with silicon integrated circuits for more capability at each pixel; and prototyping a new, highly compact clock that will aid in navigation and timing for small platforms.			
FY 2019 Plans: Chemical sensing technology and blue-green laser developments begun in FY 2017 will conclude in FY 2019 with the demonstration of technology prototypes. This project area expects new applied research in the areas of magnetic imaging for advanced microscopes, more flexible and higher performing optical sensors, superconducting electronics, and other advanced devices.			
FY 2018 to FY 2019 Increase/Decrease Statement: There are no notable changes between FY 2018 and FY 2019.			
Title: Optical Systems and Technologies	4.577	5.540	5.600
Description: This project area conducts applied research and develops novel concepts, technologies, and systems to be used in next-generation optical systems for the DoD. Investments in optical-based technologies can fill the critical technology gaps			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
in emerging DoD threat areas, such as anti-access/area denial (A2/AD), counter–weapons of mass destruction (C-WMD), and asymmetric warfare. Optical systems and technologies will also improve capabilities using new tactics, techniques, and procedures (TTPs) in traditional DoD mission areas such as intelligence, surveillance, and reconnaissance (ISR), space control, communications, and ballistic missile defense. ***FY 2018 Plans:*** Optical Systems and Technology will continue to develop technologies for high-energy lasers (HEL) that are finding many defensive and offensive DoD applications including blinding sensors and other countermeasures. Research in computing-intensive algorithms as well as more capable focal plane arrays will demonstrate higher resolution images. Until now, a laser radar on a large aircraft produced three-dimensional (3D) images only after hours of processing on the ground. Development of a small laser radar in FY 2018 will allow real-time 3D images on a small unmanned air vehicle. Microwave radars with multiple receivers have many advantages including multiple look angles, stealthy receivers, and higher resolution. Research with simultaneous microwave beams and optical beacons will explore techniques to overcome synchronization and coherent combining difficulties. The ability for wavelength agility will become as important in the optical domain as it is for microwave electronic warfare. So, development of multi-wavelength imaging spectrometers, long-wavelength infrared laser radars, and wavelength-agile short pulse lasers will provide continued capability growth while ensuring that deployed countermeasures in overused optical regions will not thwart DoD capabilities. ***FY 2019 Plans:*** Design will commence on integration of a 3D laser radar into an unmanned air vehicle. Continue development on optical coherent combining which will enable a wide variety of applications in areas of HELs, optical imaging, multi-wavelength signal processing, and communications. Although coherent combining of optical beams is many decades old, technology has only recently advanced enough to enable many DoD applications. The most promising of these will be developed in FY 2019. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** There are no notable changes between FY 2018 and FY 2019.			
Title: Radio Frequency (RF) Systems and Technologies ***Description:*** This project area focuses on research, development, and evaluation of innovative RF technologies and system concepts for radar, signals intelligence, electronic warfare, and communications. Emerging national security challenges include a rapidly expanding threat spectrum, the increasing need to integrate sensors on platforms with severely constrained payloads, military operations in strong clutter and interference environments, detection and long duration tracking of difficult targets, and robustness against sophisticated electronic countermeasures. To address these new mission requirements, future RF systems will need to operate with increased bandwidth, higher dynamic range, higher-frequency bands, and lower size, weight and power (SWAP).	3.661	4.195	4.200

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2018 Plans: RF Systems and Technology will continue to focus research on advanced RF technologies in support of emerging needs for radar, electronic intelligence (ELINT) communications, and electronic warfare (EW) systems. The major research areas include: advanced RF arrays that deliver higher power and efficiency; wideband receivers for ELINT applications; simultaneous transmit and receive technology to enable multifunction RF systems; micro-hydraulic-jet technology for RF electronics cooling; and algorithm techniques for RF countermeasures. ***FY 2019 Plans:*** The GaN on Si CMOS technology development will continue with an advanced prototype test. The wideband ELINT receiver development will continue, with a major intermediate milestone to demonstrate a prototype breadboard. The fiber-combining RF array project will develop critical enabling components. This project area expects new applied research in electronic warfare algorithms, transmit beam processing to increase RF system flexibility and performance, applications of 3D manufacturing to RF components, and other RF capability areas. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** There are no notable changes between FY 2018 and FY 2019.			
Title: Information, Computation, and Exploitation Sciences	5.089	5.788	5.860
Description: This project area achieves technical gains in data processing, computation, exploitation, and information visualization for DoD applications. The volume, velocity, and variety of information production and consumption are growing at exponential rates. Novel computing architectures, hardware and analytical techniques provide tools to process “big data”. These tools for high throughput processing, fusion, interpretation, and exploitation of “big data” are applied to both real-time and stored multi-sensor, multi-intelligence data sets. ***FY 2018 Plans:*** Several highly publicized attacks on computer networks were promulgated using unsecured Internet of Things (IoT). In FY 2018, an IoT project will prototype resilient cloud computing techniques in IoT networks to protect military systems. Advanced machine learning efforts will expand to national security environments where tagged training data are sparse. Sparse data introduces hurdles that are not being addressed in the commercial world. The new techniques will help the warfighter make better decisions based on current knowledge in a timely way. New real-time processing approaches such as the graph processor effort will reduce size, weight, and power (SWAP) to allow advanced analytics to be deployed at the tactical edge. ***FY 2019 Plans:*** Transition of the graph processor technology to use in the Supercomputing Center will be completed to test. Also, work will continue to focus on providing enough information for decision making at the tactical edge through increased efficiency of available information and machine learning techniques. Applied research will continue on the use of deep learning techniques for			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
data exploitation, with an emphasis on designing algorithms that are both efficient and that can explain their decision processes to humans. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** There are no notable changes between FY 2018 and FY 2019.			
Title: Biomedical Sciences and Technology ***Description:*** This project area develops advanced biomedical technology and systems to address health needs to enhance warfighter resilience and sustainability. The projects exploit expertise in advanced signal processing, optoelectronics, systems engineering and analysis, biology and chemistry, and other fields to develop novel methods and devices for interrogating and understanding physiological and cognitive aspects of the human domain. The overarching goal of these efforts is to increase human performance and prevent or predict injury through improved understanding of the biological mechanisms of disease and injury and through individualized biological monitoring, analysis, and interventions. ***FY 2018 Plans:*** Advance understanding of the human brain, developing better diagnostics for cognitive load assessment and illnesses like mild Traumatic Brain Injury (mTBI), and improving field forward casualty care will facilitate diagnostics for and improvements in warfighter health and resilience. Several efforts are augmenting the Brain Research through Advancing Innovative Neuro-technologies (BRAIN) initiative being led by the Defense Advanced Research Projects Agency (DARPA) and The National Institutes of Health (NIH), and include the development of algorithms for cellular resolution brain mapping, the design and prototyping of neuron-size, biocompatible sensors for in-vivo neural monitoring, as well as the design and development of novel sensors for imaging systems to make them portable for use in the field and office to diagnose post-traumatic stress or brain injury, and to conduct real time cognitive load assessment for the warfighter. Sensorimotor tracking of neurological disorders in a large virtual reality environment is informing the detection of mTBI, with a focus on transitioning a simplified version of the capability to clinical settings. Other efforts are targeted at developing and implementing novel model systems and sensors, medical support tools, and the application of big data analytics to areas such as medical image analysis. Novel model systems and sensors include: the Lincoln Laboratory Artificial Gut that is helping to decipher the complex relationship between the nervous system and the microbiome, which has been correlated with depression and stress, as well as neuro-generative diseases including Parkinson's Disease; and development, design and prototyping of an engineered sensor platform capable of real-time monitoring of health biomarkers in the body or in body fluids. Novel medical support tools include: a novel hearing aid design that uses deep neural networks to reduce the cognitive burden of isolating a single speaker in background noise, which is of relevance for normal and hearing impaired warfighters; and implementation of artificial intelligence to develop a system for field forward casualty care that reduces the burden on medics providing combat casualty care. ***FY 2019 Plans:***	4.166	4.812	5.100

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Better understanding and harnessing of Human Machine Interfaces (HMI) will become increasingly important for the DoD. The Laboratory will incorporate results of the FY 2018 Laboratory HMI systems analysis study to chart a path forward to address identified knowledge and capability gaps aligned with DoD needs. Biomedical Sciences and Technology will continue to place an increasing emphasis on multimodal data collection and analysis in diverse application areas for example, cognitive and neuroscience, microbiome-related, tissue healing, in keeping with emergent science trends and anticipated DoD needs. The increased understanding will also aid in treatment of soldiers with traumatic brain and other battlefield injuries. This project area will continue to develop concepts and technologies in medical sensing, imaging, and diagnostics, cognitive analytics, and cellular and molecular engineering. Multimodal approaches to understanding physiological and psychological status will continue. Novel tool and platform development focused on accelerating and improving biotechnology research will also continue. Medical image processing and rehabilitation tools will be explored by leveraging existing Laboratory expertise in image processing, signal analysis, and decision support algorithms. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** The increase in funding will accommodate expected additional research, informed by the Laboratory's HMI systems analysis study, as this is a significant growth area for the DoD, and ensure the successful continuation and continued results of ongoing projects.			
Title: Autonomous Systems	3.401	3.904	4.100
Description: This project area addresses current and anticipated DoD mission needs in autonomous robotics. In DoD environments, unmanned systems must perform useful tasks as trusted, capable agents without continuous human operator control. Projects include development of autonomy algorithms and technologies, such as perception and world modeling, planning, human-robot interaction, manipulation, learning and adaptation, and robotic platforms. ***FY 2018 Plans:*** Coordination of robot swarms will continue to add features that allow optimization of goals even with a great deal of uncertainty for example, "the fog of war". These improvements rely on continuing research in multi-agent coordination and machine learning algorithms. One learning algorithm project will emulate biological thinking for adapting to changing knowledge. Advances in autonomous systems rely not only on improved algorithms, but also better interfaces between hardware and algorithms, as well as more suitable hardware. This project area will conduct research into better tactile interfaces for grasping and manipulation, with an additional focus on building autonomous systems that will perform within prescribed performance bounds. These research thrusts will have important applications in autonomous robot augmentation for the warfighter. Also, being aware that the noise of an autonomous Unmanned Aerial Vehicle (UAV) can compromise its mission, work on an electroaerodynamic (EAD) propulsion system will lead to sustained noiseless flight. In addition, a study will provide an autonomous undersea mapping framework for future efforts. ***FY 2019 Plans:***			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
As autonomous systems play an increasingly important role in the DoD, work in autonomous undersea mapping will rely on new algorithms, new autonomous undersea vehicles, and communications to interface between distributed sources of information and distributed, multiple agents. Research on EAD UAVs will continue to improve performance and make the system more robust. Incorporation of algorithms from the commercial world will hasten the development of autonomous systems for the DoD. Incorporation of technology improvements from the commercial world will lead to improvements in lower Size, Weight, Power and Cost (SWaP-C) systems. Novel energy harvesting strategies will be explored to support a variety of missions. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** There are no notable changes between FY 2018 and FY 2019.			
Title: Quantum System Sciences	4.437	5.160	5.200
Description: This project area develops methods for sensing, communicating, and processing information using quantum mechanical manipulation not possible with classical computing techniques. Collaborations with major university quantum system science efforts are establishing a robust scientific foundation. On this foundation, application-oriented developments important for national security are being fostered. ***FY 2018 Plans:*** A unique feature of quantum mechanical manipulation is the correlation property, particularly for entangled states. Research takes advantage of these states to produce secure quantum networks and quantum computers, which, in principle, can do calculations far beyond the ability of any classical computer. A quantum communications system has been built over an in-ground fiber in the Boston metropolitan area. This system will continue to develop and test a robust and secure quantum network with applicability to a secure core network for the DoD. Quantum computing could have important implications for solving DoD problems that are intractable on classical computers. Multiple techniques for overcoming technical difficulties are being investigated. For example, advances in control and measurement of trapped ion and superconducting qubits will enable the development of noise correlation measurements and error correction techniques. These advances are a requirement for quantum computers. FY 2018 plans also include design of a fieldable, high-precision vector magnetometer based on advances in quantum magnetometry. This project area will also investigate electric field measurements that are based on the same physics and that employ much the same hardware as used for the magnetometer. ***FY 2019 Plans:*** Research will place an emphasis on approaches to do quantum state transfer between a trapped ion and photon and leverage the ions for quantum sensing and quantum clocks. A linchpin for both quantum networks and quantum computers is the ability to manipulate robust quantum memories. Advances in quantum memories will build on the improved control and measurement techniques of FY 2018. Improved measurements based on sub-shot noise interferometry using entangled states will enhance microwave links over optical fiber, which has important applications for remoting of antennas. FY 2019 plans also include scaling			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
quantum computer prototypes and investigating improved control and error correction mechanisms, as well as developing increased bandwidth quantum networking capability. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** There are no notable changes between FY 2018 and FY 2019.			
Title: Advanced Materials and Processes ***Description:*** This project area (formerly named Novel and Engineered Materials) develops materials and processes that make a transformative impact on enduring national challenges. Areas of strategic focus are material property customization and material enablers for much lower SWaP systems. ***FY 2018 Plans:*** Lincoln Laboratory leverages additive manufacturing for materials discovery and property customization. Research into multimaterial fibers showed in FY 2017 unique long-wavelength properties. When woven into cloth in FY 2018, the cloth should make soldiers significantly less visible to heat-sensing cameras. This project area recently developed materials with large optical property changes in sub-millisecond times. Lincoln Laboratory continues to FY 2018, we will develop prototypes to improve this capability. Further work in FY 2018 will apply these materials to DoD and IC applications. This project area will conduct research into ”valleytronic” materials, which have the potential to deliver extremely low-power memory and computing capability. ***FY 2019 Plans:*** Gaining proper understanding of valleytronic materials will require several years of research. This project area will conduct research and development of new valleytronic materials and phenomenology. The project will also develop novel fibers with unique physical, chemical, or biological properties that can be integrated into fabric or other materials, which could revolutionize warfighter protection and capabilities. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** There are no notable changes between FY 2018 and FY 2019.	2.500	3.075	3.100
Title: Integrated Systems ***Description:*** This project area combines multiple new technologies to solve important national needs. Projects selected for funding have an applied research component focused on integrated technology capability or technologies that facilitate greater levels of integrated capability. Projects target key DoD warfare domains, including space, air, land, sea surface, and undersea. The intent is to support early work on systems that cut across the conventional categories. ***FY 2018 Plans:*** This project area will continue two projects from FY 2017 and evolve two projects from other technology areas. The undersea laser communications project will refine the pointing-and-tracking technology needed to accomplish narrow beam	2.295	2.910	3.100

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
communications, and will do in-water testing of a communication network between multiple moving platforms. The 3D space-based ladar effort will continue with risk reduction in key areas, including data-registration for forming 3D image and space optics technology. The project will accelerate the design of a future generation micro-air vehicle (MAV) for integrating advanced power, guidance, control, and payloads. Maturation of wafer-scale integration processes will lead to development of designs for applying these processes to small satellite systems. ***FY 2019 Plans:*** The four efforts will continue in FY 2019. The undersea laser communication project will conclude with a multiple undersea vehicle communication demonstration. The 3D ladar project will complete risk reduction activities (described above) and will proceed to a preliminary design review for a critical space surveillance mission. The future generation MAV project will focus on integrating advanced sensing payloads and advanced autonomous system processing control algorithms. The plan is to develop a highly integrated wafer-scale small satellite bus with a basic payload. This satellite bus will be a highly integrated capability with embedded thrusters, control, and space for small form factor payloads. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** The increase in funding in FY 2019 will accommodate increased development costs of maturing projects.			
Title: Cyber Security, Science and Engineering	3.500	3.500	0.000
Description: The Cyber Security Science and Engineering Program focuses on the development of technologies and new techniques for the protection of systems against cyber-attack and exploitation. Projects include research into technologies for cyber situational awareness, command and control; technology to improve resilience of systems to cyber-attack; and technologies for system exploitation research. ***FY 2018 Plans:*** Plans include advancing the capability to discover and rapidly respond to cyber vulnerabilities, as well as improving significantly the design and architecture of embedded computer systems and data management systems, which will facilitate improvements in DoD cyber security and resilience. Research into novel approaches for computer hardware/software design will guide the design and development of a fundamentally new computing system that is inherently secure and can ensure mission success even when compromised. This effort will be complemented by developing a data-centric approach to ensuring self-protection of data throughout storage, computation and transit. Research into cyber resilient approaches for mission assurance includes the development and implementation of a secure processing engine for autonomous systems, and the development and validation of an automated capability for contested environments where a host may be disabled or compromised. Other cyber efforts include further developing the capability to automatically generate effective cyber courses of action for evolving threat environments such as damage by an attacker after network penetration, securing small satellites against the growing threat of cyber-attack, and			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
securing the ability to compute on private data without revealing it and demonstrating this capability for a Department of Homeland Security (DHS) application. ***FY 2019 Plans:*** Cyber efforts will move to an individual project code starting in FY 2019. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** There are no notable changes between FY 2018 and FY 2019, where the latter is reported in an individual project code starting in FY 2019.			
Accomplishments/Planned Programs Subtotals	38.126	44.275	41.359

C. Other Program Funding Summary ($ in Millions)

N/A

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) 535 / *Technical Intelligence*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
535: *Technical Intelligence*	17.905	8.374	5.473	6.737	-	6.737	6.743	6.839	6.960	7.092	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Technical Intelligence Program supports the strategic intelligence analysis through providing global science and technology (S&T) awareness and context in order to inform Defense technology, engineering & acquisition decision-makers planning for an uncertain future. The program exploits novel technology watch and horizon scanning (TW/HS) tools to identify nascent and disruptive technologies that will shape tomorrow's future by integrating intelligence-based and open-source information to characterize today's global S&T environment, this characterization, in combination with other technical analysis, will inform strategic decisions for capability development. The program complements this with tailored technical assessments that identify the military relevance, research opportunities, and policy recommendations for emerging and disruptive technologies.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Technical Intelligence	8.374	5.473	6.737

Description: The Technical Intelligence Program supports the strategic intelligence analysis through providing global S&T awareness and context in order to inform Defense technology, engineering & acquisition decision-makers planning for an uncertain future. The program exploits novel TW/HS tools to identify nascent and disruptive technologies that will shape tomorrow's future by integrating intelligence-based and open-source information to characterize today's global S&T environment, this characterization, in combination with other technical analysis, will inform strategic decisions for capability development. The program complements this with tailored technical assessments that identify the military relevance, research opportunities, and policy recommendations for emerging and disruptive technologies.

FY 2018 Plans:

In FY 2018, the Technical Intelligence program will continue to support efforts characterizing today's global S&T environment, exploiting novel TW/HS tools to identify nascent and disruptive technologies that will shape tomorrow's future, and developing tailored technical assessments that identify the military relevance, research opportunities, and policy recommendations of emerging and disruptive technologies. Specifically:

• TW/HS Tool Exploitation: ($3.5M) will continue to support the operational TW/HS toolkit, TechSight, which is available to DoD researchers and scientists, and focus on expanding it to provide quicker data analytics for TW/HS to support decision making through the inclusion of DoD contract, small business innovation research (SBIR) and grant award information. These developments will allow for strategic analysis of S&T and acquisition investments to inform technology, engineering, & acquisition decisions. The program will identify outreach opportunities to inform and train DoD S&T organizations in the usage of analytical tools and methodologies to support "in-house" decision making and expand organizational knowledge into emerging technology areas of strategic interest.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Office of the Secretary Of Defense		Date: February 2018
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602234D8Z / *Lincoln Laboratory*	**Project (Number/Name)** 535 / *Technical Intelligence*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
• Technical Assessment Program: ($0.5M) will sponsor multiple technical assessment activities that support the community of interest topic areas and more emphasis will be placed on conducting impact assessments of emerging technologies. These assessments will inform the S&T community on direction for future capabilities to support joint and cross domain missions. • Intel Support to S&T: ($1.0M) will provide a bridge between the intelligence community (IC) and the S&T community to access the most relevant intelligence analysis, coordinate integration of intelligence with capability development, and conduct Red Cell assessments to inform technology investment shaping and strategic direction. An additional function will be to produce an annual S&T Intelligence Needs Plan providing the IC a formal understanding of intelligence requirements for the R&D community. • Wargaming: ($0.5M) will integrate emerging threats from kill chain analysis and potentially disruptive technologies from horizon scanning efforts through the DoD wargaming community to better understand the potential of emerging technologies to better inform both the DoD requirements process and the technical capability development process. ***FY 2019 Plans:*** In FY 2019, the Technical Intelligence program will continue to support efforts characterizing today's global S&T environment, exploiting novel TW/HS tools to identify nascent and disruptive technologies that will shape tomorrow's future, and developing tailored technical assessments that identify the military relevance, research opportunities, and policy recommendations of emerging and disruptive technologies. Specifically: • TW/HS Tool Exploitation: ($4.7M – Additional Data sources) will continue to support the operational TW/HS toolkit, TechSight, which is available to DoD researchers and scientists, and focus on developing data analytics on the commercial sector through analyzing venture capital, private equity and commercial investments in R&D. • Technical Assessment Program: ($0.5M) will sponsor multiple technical assessment activities that support the community of interest topic areas and more emphasis will be placed on conducting impact assessments of emerging technologies. These assessments will inform the S&T community on direction for future capabilities to support joint and cross domain missions. • Intel Support to S&T: ($1.0M) will provide a bridge between the intelligence community (IC) and the S&T community to access the most relevant intelligence analysis, coordinate integration of intelligence with capability development, and conduct Red Cell assessments to inform technology investment shaping and strategic direction. An additional function will be to produce an annual S&T Intelligence Needs Plan providing the IC a formal understanding of intelligence requirements for the R&D community. • Wargaming: ($0.5M) will integrate emerging threats from kill chain analysis and potentially disruptive technologies from horizon scanning efforts through the DoD wargaming community to better understand the potential of emerging technologies to better inform both the DoD requirements process and the technical capability development process. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Increase resources to support technology watch and horizon scanning in order to inform the DoD R&D investments.			
Accomplishments/Planned Programs Subtotals	8.374	5.473	6.737

Exhibit R-2A, RDT&E Project Justification: PB 2019 Office of the Secretary Of Defense		Date: February 2018
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602234D8Z / *Lincoln Laboratory*	**Project (Number/Name)** 535 / *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 2019 Office of the Secretary Of Defense			Date: February 2018
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602234D8Z / *Lincoln Laboratory*	Project (Number/Name) 815 / *Cyber Security, Science and Engineering*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
815: *Cyber Security, Science and Engineering*	-	0.000	0.000	3.500	-	3.500	3.500	3.500	3.500	3.500	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Cyber Security Science and Engineering Program focuses on the development of technologies and new techniques for the protection of systems against cyber-attack and exploitation. Projects include research into technologies for cyber situational awareness, command and control; technology to improve resilience of systems to cyber-attack; and technologies for system exploitation research.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Cyber Security, Science and Engineering	0.000	0.000	3.500

Description: The Cyber Security, Science and Engineering Program conducts research, development, evaluation, and deployment of prototype components and systems designed to improve the security of computer networks, hosts, and applications, thereby assuring the resilience of Department of Defense (DoD) missions against cyber-attack and exploitation. A particular focus is the overlap between the DoD mission areas and the cyber domain. Efforts include cyber analysis; creation and demonstration of robust architectures that can operate through cyber-attacks; development of prototypes that demonstrate the practicality and value of new techniques for cryptography, cyber sensing, automated threat analysis and course of action selection, anti-tamper systems, and malicious code detection; demonstrations of the impact of cyber on traditional kinetic systems; quantitative, repeatable evaluation of these prototypes; and, where appropriate, deployment of prototype technology to national- and international-level exercises and DoD and intelligence community operations.

FY 2018 Plans:
Cyber efforts were previously funded under Project P534 in FY 2018 and prior.

FY 2019 Plans:
Plan to improve the capability to rapidly respond to evolving cyber threats and new technology trends, and guide future plans for cyber security. Further develop the design and architecture of novel cyber resilient computer systems and data management systems, as well as capabilities and tools to support mission assurance. Plan is to focus on big data analytics in support of cyber situational understanding and effective, timely decision making; these capabilities will play a key role in future applied research. Continue to develop prototype cyber decision support systems that can automatically generate effective cyber security courses of action to protect systems under attack.

FY 2018 to FY 2019 Increase/Decrease Statement:

Exhibit R-2A, RDT&E Project Justification: PB 2019 Office of the Secretary Of Defense		Date: February 2018
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602234D8Z / *Lincoln Laboratory*	**Project (Number/Name)** 815 / *Cyber Security, Science and Engineering*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
No notable change between FY 2018 (under Project P534) and FY 2019			
Accomplishments/Planned Programs Subtotals	0.000	0.000	3.500

	FY 2017	FY 2018
Congressional Add: N/A	0.000	0.000
FY 2017 Accomplishments: N/A		
FY 2018 Plans: N/A		
Congressional Adds Subtotals	0.000	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A