RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE JUNE 2001	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense Wide/BA 2							R-1 ITEM NOMENCLATURE Lincoln Laboratory **PE 0602234D8Z**			
COST *(In Millions)*	FY2000	FY2001	FY2002						Cost to Complete	Total Cost
Total Program Element (PE) Cost	20.081	19.917	21.969						Continuing	Continuing
Lincoln Laboratory/P534	20.081	19.917	21.969						Continuing	Continuing

(U) A. Mission Description and Budget Item Justification

(U) BRIEF DESCRIPTION OF ELEMENT

(U)The Lincoln Laboratory (LL) program is a high technology research and development effort conducted through a cost reimbursable contract with the Massachusetts Institute of Technology (MIT). LL is operated as a FFRDC administered by the DoD, and is unique among DoD FFRDCs. It has no funding sources other than the Line for its innovative research and development efforts. This is due to the fact that LL is operated by MIT at no fee and may not charge for IR&D (under A-21). Other DoD FFRDCs do charge a fee with which they may support research efforts.

(U)The LL Line funds research activities that directly lead to the development of new system concepts, new technologies, and new components and materials. Historically, the Line funding supported many development and demonstration programs which have led to such significant DoD systems as JSTARS, MILSTAR, GEODSS, as well as to solid-state devices and processes of major importance to the military industrial base. In addition to being the foundation for many new LL programs, the Line also supports other ongoing Laboratory programs with state-of-the-art technology developments. The program has the following 4 research elements:

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• Target surveillance and recognition, with emphasis on (1) revolutionary sensing techniques and algorithms for detecting and recognizing battlefield targets both in the clear and in difficult deployments, (2) supporting data collection and phenomenology, (3) fundamental target-recognition bounds and their implications for sensor and algorithm design, and (4) revolutionary new approaches for automated passive sonar target classification of submarine targets and discrimination of submarines from surface ship clutter.
• High-connectivity, low-cost military global defense network and communications systems, with emphasis on new antennas, RF technology, network protocols (including for mobile users with lightweight transceivers), high-rate fiber and free-space optical communications systems, and the interconnection of these very disparate modalities into a global defense network that can truly realize the vision of a `from sensor to shooter` communications infrastructure which will greatly enhance force effectiveness by providing the right information at the right time anywhere in the world;
• Advanced combat support technologies for active hyperspectral sensing systems and compact biological agent detection systems. The focus in biological agent detection is in developing technology for compact, lightweight, real-time biological-agent sensors with extremely high sensitivity (< 1 agent containing particle per liter of air) and with strong background clutter rejection for extremely low false-alarm rate (< 1 per week). The primary objective for the active hyperspectral sensing system development is to demonstrate the feasibility and utility of combining active illumination with hyperspectral imaging for a range of military applications including CID.
• Revolutionary, advanced electronic/optical technology, with specific emphasis on optical sampling for direct analog-to-digital conversion on the microwave carrier in digital receivers for radar and electronic intercept, 3-D imaging and high sensitivity IR focal-plane arrays for advanced missile seekers, mid-infrared semiconductor lasers to counter advanced heat-seeking missiles, new miniature fluorescent and microfluidic sensors for rapidly detecting and identifying low concentrations of biowarfare agents, solid state low-light imagers for improved night vision under starlight illumination, and high-speed, radiation hard, ultra-low power analog and digital circuits for ubiquitous DoD applications.

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COST*(In Millions)*	FY 2000	FY 2001	FY 2002						Cost to Complete	Total Cost
Total Program Element (PE) Cost	17.081	19.917	21.969						Continuing	Continuing
Lincoln Laboratory/P534	17.081	19.917	21.969						Continuing	Continuing

(U) Project Number and Title: P534 Lincoln Laboratory

(U) PROGRAM ACCOMPLISHMENTS AND PLANS

(U) FY 2000 Accomplishments:

(U) Target Surveillance and Recognition:

(U) Surface Surveillance:

(U) Extend fundamental target-recognition bounds to multi-look, multi-frequency and polarimetric sensing. Initiate formulation and analysis of multi-sensor concepts for high-performance, resource-efficient wide-area battlefield target recognition. Continue theoretical and experimental investigation of sparse-array techniques for active seismic imaging of underground facilities. In addition to being directly applicable to ongoing R&D efforts such as DARPA`s MTE, MSTAR and underground-facilities programs, these activities will have considerable significance for organizations, such as NIMA, NRO and the Services, that are planning and developing next-generation sensing and exploitation systems.

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(U) Space Surveillance

(U) Continue 3-D laser radar technology development with the final hybridization of 32 x 32 avalanche photo-diode (APD) arrays with arrays of CMOS timing electronics. These arrays will be incorporated into the brassboard system for the demonstration of single-photon-sensitivity 3-D imaging for advanced BMD and tactical seekers. Begin the development of APD arrays, which are sensitive at 1.5-micron wavelengths, for use with eyesafe laser transmitters. This will include the development of single-element and small arrays of diffusion-bonded structures utilizing an InGaAs absorption region and a silicon avalanche region. These APD arrays will be compatible with the co-developed CMOS timing circuitry and will enable 3-D laser radar systems for use in combat-identification and vehicle-navigation applications as well as tactical seekers in urban environments where laser eyesafety is a requirement. Begin the development of a laser-transmitter system that incorporates the multi-functional capability of 3-D laser radar and laser-vibration sensing. This system would incorporate APD arrays for the 3-D imaging along with a long-coherence-time mode-locked laser transmitter, which would allow coherent detection for vibration measurements and has applications in combat identification.

(U) Sonar Target Classification Continue to investigate the benefit of improved front end beamforming techniques but focus more on the impact of improved features on classifier and overall system performance. Explore and demonstrate adaptive techniques for array calibration to improve sonar performance during ownship maneuvers. Strong interfering surface ships can serve as sources of opportunity that can be used to automatically calibrate or estimate array shape. The estimated shape will then be used directly within the beamformer to improve target SNR.($ 4.172 million)

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(U) Military Communications:

(U) Continue to investigate technology for global high-rate military communications and networking at rates from tens of megabits to tens of gigabits per second, including optical communications and tactical theater communications (particularly to Army forces on the move). Global ultra-high-rate networking: Initial implementation of ultra-high-rate optical network from Lincoln Laboratory to Washington, DC under funded programs; will be available for demonstrations of line-funded fiber optic communications techniques. Demonstrate 100 Gbps packet assembly, transmission and reception over optical fiber in laboratory testbed. Develop novel applications using high-speed optical backbones such as cooperative processing of radar data and other applications. Tactical Satellite Terminals: Complete transfer of technology of optically controlled phased array antennas into funded radar and communication programs.

(U) Defensive Information Warfare: Bottleneck Verification System will be further refined and evaluated, then will be extended beyond looking for illegal user-to-root transitions to other attack classes and mechanisms. This technology will be transferred to AFWIC for deployment over a wide range of Air Force base computer networks. The set of information assurance components in the yearly product evaluation will be extended to encompass protection (e.g. firewalls) and reaction (e.g. security service desks) subsystems in addition to ID subsystems. Begin development of systems that can identify and not merely detect intrusion attacks. ($ 3.656 million)

(U) Combat Support Technology:

(U) Active Hyperspectral Sensing Systems: Extend the operating spectral region of both the white light `laser` and the spectral imaging systems from VIS/NIR to encompass 3 to 5 micron bands. Continue processing algorithm development in order to identify key features for target recognition and visualization using the extended sensing capability. This system will continue to be tested in both laboratory and field environments on a variety of targets and scenarios of military interest. Design of a full-spectral system, spanning the visible through infrared bands will be initiated and the factors affecting fusion with other sensing systems, such as synthetic-aperture radar and other EO sensors, will be examined.

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(U) Biological Agent Detection Systems: The work will begin to focus on a miniature, low-power sensor incorporating a UV fluorescence sensor at the front end, a B-cell-based identifying sensor at the back end, and stages of intelligent particle sampling and sample purification in the middle. For the UV sensor, work will continue on reducing the laser power requirements, and work will begin on aggressively miniaturizing the sensor. Development will begin on a fully intelligent, integrated particle sampler and on the microfluidic sample-purification sub-system. Modeling and sisimulation efforts will continue with emphasis on how the integrated sensor would perform in urban environments. In addition, work will continue on cartridge-based soil measurements and on background measurements. These technology efforts will flow into the Joint Biological Point Detection System (JBPDS) and into the Joint Biological Remote Early Warning System (JBREWS) ACTD.($ 4.536 million)

(U) Advanced Electronics Technology: Extend direct RF optical sampling to bandwidths beyond 100 MHz by demonstrating scalable methods for parallelizing quantizers: Begin system demonstration of utility of optical sampling for digital receivers at radar field site. Improve materials and spectral combining techniques enabling higher-brightness and higher-operating-temperature optically pumped mid-IR semiconductor lasers for IRCM applications. Reduce dark current levels and develop CMOS-based versions of visible, UV and IR focal planes in support of AF, DARPA, and other DoD programs. Continue development of advanced silicon process technology with extensions of CMOS to sub-100-nm feature sizes, with emphasis on development of technologies for on-focal-plane processing, radiation-hard technologies, and integrated sensors. Continue development of tunable superconductive RF filters for frequency-agile receivers. Demonstrate 4-GHz bandwidth ELINT receiver incorporating superconductive chirp filters and CMOS/SOI data processor. Continue development of bio-detector technology based on integration of living biological cells with microfluids and microelectronics with emphasis on discrimination and identification methodologies. Demonstrate 3-D radar subsystem incorporating a 32x32 array of geiger-mode avalanche photodiodes (APD), integrated timing electronics, and compact laser illuminator. Demonstrate APD arrays for use at eye-safe wavelengths applications. Demonstrate microelectromechanical (MEM) RF tuning structures for electronically reconfigurable microwave receivers and antennas. Initiate development of AlGaN UV detectors for solar- blind applications.($ 4.717 million)

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(U) FY 2001 Plans:

(U) Target Surveillance and Recognition:

(U) Surface Surveillance:

(U) Develop and apply absolute (vs. relative, between two sensor designs) fundamental ATR performance bounds. Apply multi-sensor ATR concepts to development of practical multi-sensor ATR architectures for high-performance, resource-efficient, wide-area battlefield target recognition. Design field experiments to demonstrate such architectures. Refine techniques for sparse-array active seismic imaging and demonstrate an existing underground facility. In addition to being directly applicable to ongoing R&FD efforts such as DARPA`s MTE and MSTAR programs, these activities will have considerable significance for organizations, such as NIMA, NRO and the Services, that are planning and developing next-generation sensing and exploitation systems.

(U) Space Surveillance:

(U) Continue 3-D laser radar technology development with the scaling of the array sizes to greater than 32 x 32 pixels. These larger arrays will have applications for advanced BMD and tactical seekers and ground mapping and foliage penetration. Continue the development of 1.5-micron-sensitive APD arrays with the scaling of the single-element and small arrays to 32 x 32, or larger, array sizes. These devices will enable the single-photon-sensitive 3-D laser radar technologies to be used in the eyesafe regime for applications such as combat identification and tactical seeker homing in urban environments. Continue the development of multi-function laser transmitters, which are capable of 3-D imaging and laser-vibration sensing, for applications of combat identification and underground-structure sensing.

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(U) Sonar Target Classification Expand application of IPAC classification approach beyond submarine towed array sonars to the fixed (SOSUS) and mobile (SURTASS) surveillance problems. Develop techniques for operator in-situ training and test with field data. Develop dynamic databases to permit sonar to exploit knowledge of environment, intelligence information, external sensor data on surface ship clutter.($ 4.078 million)

(U) Military Communications:

(U) Continue to develop technology for global high-rate military communications and networking, including optical communications in space and fiber. Continue demonstration and extension of networking techniques and protocols for interworking among disparate networks including Milsatcom. Complete testing of ultra-fast optical testbed with 100 Gbps transmissions between Lincoln Laboratory and Washington, DC (application to surveillance data processing). Investigate novel application areas for optical technology such as ultra-fast data encryption and processing.

(U) Defensive Information Warfare: Development and evaluation of advanced techniques for network intrusion detection will continue. Focus will shift towards detection of insider attacks (i.e. attacks from users who have authorized access to the system). Build systems that process complementary data from an ensemble of cooperating intrusion detection systems, for improved aggregate performance. Develop systems that can determine an attacker`s intent.($ 3.404 million)

(U) Combat Support Technology:

(U) Active Hyperspectral Sensing System: Develop a full-spectral active HSI system, using select, discrete-frequency laser wavelengths throughout the visible through mid-wave IR spectral regions, broadband illumination in discreet segments of those regions, and passive long-wave IR imaging. The system will be adaptable, where both the sensing wavebands and target-recognition algorithms will be specified by the applications. For some applications, visible APD arrays will be incorporated that permit range-resolved imaging as well as the standard spatial and spectral imaging that the active HSI system affords. Effort will also be expended in developing real-time processing and visualization schemes for either direct relay to user or transmission to a control station for fusion of multiple sensing assets.

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(U) Begin to explore how to adapt B-cell-based sensor for integrated package. This technology development may feed into an integrated, miniature low-power sensor at a later date.($ 2.014 million)

(U) Advanced Electronics Technology:

(U) Investigate highly scaled CMOS/SOI digital circuits using mixed electron-beam and optical lithography at 25-nm feature sizes for ultradense circuits. Explore integration of ICs in the third dimension as a means to significantly improve functional density. Demonstrate compact and power efficient version of optically sampled A/D with multi-GHz bandwidth for radar and electronic intelligence use. Extend highly integrated CCD/CMOS imager to include noiseless jitter compensation of platform motion. Continue development of UV, visible, IR and hyperspectral imaging devices with on-focal-plane processing for `smart` multimode sensors. Transfer advanced mid-IR semiconductor laser technology to industry for dual-wavelength IRCM. Continue development of combined biochemical, micromechanical, electronic systems. Continue development of solid-state devices, materials and processing subsystems in support of DoD programs.($ 5.195 million)

(U) Congressional add($ 5.226 million)

(U) FY 2002 Plans:

(U) Target Surveillance and Recognition

Surface Surveillance:

(U) Extend integrated capability to automatic detection and identification of high value targets like Surface-to-Air Missiles. This capability will build upon the trainable search agents an use terrain features as contextual information to help the target recognition process. Focus will center on the automatic target recognition of SA-6s from overhead data and reducing the processing latencies associated with these time-critical targets.

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(U) Collect data with airborne sensor to support development of advanced operational concepts and ECCM and ATR algorithms.

(U) Analyze the requirements for a system that will use the algorithms developed to image underground facilities. Consider sensors, processing, calibration and communications requirements. Continue relevant measurement to understand phenomenology and tune and validate imaging algorithms.

(U) Sonar Target Classification

(U) Develop dynamic database concepts to permit sonar to better exploit knowledge of environment, intelligence information, and external sensor data on surface ship clutter. Extend Interactive Passive Acoustic Classifier (IPAC) methodology to sonar classification with multiple sensors, using the hill, sphere, and towed arrays of a typical submarine as an example. Continue (OMI) Operator-Machine Interface development. Explore benefit to classification of distributed sensor systems.
($ 4.017 million)

(U) Military Communications:

(U) Global Networks: Continue to develop technology for global high-rate military communications and networking, including optical communications in space and fiber. Continue demonstration and extension of networking techniques and protocols for interworking among disparate networks including Milsatcom. Demonstrate networked applications over MILSTAR II to facilitate ability to transfer C4ISR data in the tactical theater. Utilize high-speed fiber network between Lincoln Laboratory and Washington, DC to demonstrate movement of radar data from sensor to remote processing site for fusion with other radar data. Investigate novel application areas for optical technology such as ultra-fast data encryption and processing.

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(U) Defensive Information Warfare: Research, development and evaluation of systems that can determine an attacker`s intent will be carried out. Research on combined detection and reaction will be extended to mobile, wireless networks. Technology transfer of detection and reaction systems to military users will continue. Methodology for evaluation of intrusion detection and reaction systems will be transferred to other government organizations.
($ 4.489 million)

(U) Combat Support Technology:

(U) Active Hyperspectral Sensing System: Develop a compact system consisting of passive HSI/MSI with select, discrete-frequency laser wavelengths. The system will be adaptable, where both the sensing wavebands and target-recognition algorithms will be specified by the applications. For some applications, visible APD arrays will be incorporated that permit range-resolved imaging as well as the standard spatial and spectral imaging that the active system affords. Effort will also be expanded in developing real-time processing and visualization schemes for a number of operational concepts.

(U) Biological Agent Detection Systems: Field testing of the integrated BAWS/B-cell sensor will be conducted and non-living analogs to the B-cells investigated to enhance sensor operability. Network architectures of miniature warning/ID sensors will be tested in combined modeling and validation measurements. Sensor architectures will be considered that fuse biological with chemical sensors and appropriate response strategies. Applications for the cartridge-based nucleic-acid testing will be expanded to include real-time, in-the-field DNA analysis, and confirmation sensing.

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(U) Continue the development of laser-radar technologies for applications of advanced ballistic and tactical seekers and combat identification. This includes the development of visible and near-infrared-sensitive Geiger-mode APD arrays with bonded timing circuitry for 3-D laser radars. Upgrade the 3-D imaging brassboard system to operate at the 1.5-micron eyesafe wavelength. This will allow the functional test and demonstration of the InGaAs APD arrays. Examine the issues related to integrating these systems into lightweight, low power, packages consistent with advanced seeker applications, which will provide single-photon-sensitivity and high-precision range resolution for generating detailed 3-D imagery of targets. Continue the development of multi-function laser-radar systems, which combine 3-D imaging and range-Doppler/vibration sensing for applications of BMD interceptors, combat identification and foliage penetration. These systems will use the same laser transmitter for incoherent 3-D laser radar, utilizing the APD arrays, and coherent laser radar for target-vibration sensing. This development will involve the integration of a multi-function laser radar testbed, which will enable the collection of 3-D and range-Doppler image data on a variety of BMD-seeker related targets.
($ 6.170 million)

(U) Advanced Electronics Technology:
(U) Address improvement of CMOS/SOI yield and radiation hardness. Explore limits of optical lithography using phase-shift masking at 157-nm wavelength. Complete the 3-D stacked megapixel imager with on-chip digital image processing. Demonstrate optically sampled A/D at 1-GHz bandwidth in field radar site. Continue development of UV, visible, IR and hyperspectral imaging devices with on-focal-plane processing for “smart“ multimode sensors. Demonstrate near-IR/electronically shuttered 4-megapixel CCD imager for airborne reconnaissance. Build beam-combined high-brightness IRCM demonstration package. Develop high-power laser systems using beam-combined fiber sources and/or cooled Yb:YAG. Develop optimized super-wideband compressive receiver for airborne ELINT. Continue development of combined biochemical, micromechanical, electronic systems. Continue development of solid-state devices, materials and processing subsystems in support of DoD programs.
($ 7.293 million)

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(U) B. Program Change Summary	**FY2000**	**FY2001**	**FY2002**	**Total Cost**
Previous President's Budget Submit	20.189	18.602	18.845	Continuing
Appropriated Value		20.102		Continuing
Adjustments to Appropriated Value				
a. Congressionally Directed Undistributed Reduction	0.000	0.000	0.000	
b. Rescission/Below-threshold Reprogramming, Inflation Adjustment	-0.108	-0.131	0.000	
c. Other	0.000	0.000	3.124	
Current President's Budget	20.081	19.917	21.969	Continuing

Change Summary Explanation

(U) Funding: FY 2000 increase was the result of a below threshold reprogramming. FY 2001 reductions reflect Section 8086 adjustments.

(U) Schedule: N/A

(U) Technical: N/A

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(U) C. Other Program Funding Summary Cost: N/A

(U) D. Acquisition Strategy: N/A

(U) E. Schedule Profile: N/A