DEPARTMENT OF THE ARMY
ASSISTANT SECRETARY OF THE ARMY
RESEARCH, DEVELOPMENT AND ACQUISITION
WASHINGTON, D. C. 20310-0103

ARMY SCIENCE BOARD

REPORT OF THE ARMY SCIENCE BOARD

AD HOC SUB GROUP

REVIEW OF THE U.S. ARMY

ELECTRONICS TECHNOLOGY AND DEVICES LABORATORY

OCTOBER 1988

EXECUTIVE SUMMARY

The Electronic Technology and Electronic Devices Laboratory (ETDL) is located in the Hexagon and the Evans Area of Ft. Monmouth, NJ. The mission of ETDL is to develop and transition critical electronic technology and devices into present and future generation Army systems. The ETDL management has successfully developed and maintains a high quality technical staff. The facilities of the Laboratory are maintained at the cutting edge of new technology; in particular, the new Pulse Power Center soon to become operational will enable the Laboratory to become the DOD national asset for the development and evaluation of pulse power conditioning components for directed energy weapons, and the evaluation of high power microwave and millimeter wave devices. The technical staff and laboratory facilities have been combined to support a high quality balanced program that fully supports the mission of the Laboratory.

In order to enable ETDL to continue to maintain and improve its capabilities, to support the Armys's requirements we find that: (1) Funding requests at the 6.3A level are critical to ETDL's continued success in meeting its mission requirements, and (2) the position of a safety officer reporting directly to the Director of ETDL would be more consonant with the increased risks associated with high power testing.

TABLE OF CONTENTS

	PAGE NUMBER
Executive Summary	i
1.0 Introduction	1.
1.1 Background	1.
1.2 Panel Composition	1.
1.3 Panel Activities	3.
1.4 Acknowledgments	3.
2.0 Summary of Findings	4.
3.0 Discussion of Findings	5.
3.1 What is the quality of staff, facility and technical program?	5.
3.2 How productive is the laboratory in accomplishing its mission?	7.
3.3 How relevent is the laboratories work to important Army problems?	9.

APPENDICES

A. The Electronic Technology and Devices Laboratory interfaces within LABCOM.

B. Tasking Letter.

C. Organization and individuals contacted.

D. List of acronyms.

1.0 INTRODUCTION

1.1 Background

Past studies of Army laboratories have suggested the importance of independent effectiveness review as a means of assuring continued laboratory excellence. Consistent with the findings of these studies, at the request of the Commander of the U.S. Army Materiel Command (AMC), the Army Science Board (ASB) has initiated a series of reviews of the AMC laboratories and Research, Development and Engineering Centers. The first of these reviews was conducted during the summer of 1984. This document reports ASB findings based on a review of the U.S. Army Electronic Technology and Electronic Devices Laboratory (ETDL) conducted during the Spring of 1988.

The ETDL mission is to develop and transition critical electronic technologies and devices into present and future generation Army systems. The ETDL areas of expertise include: microelectronics, millimeter waves, microwave components, pulse power, frequency control, flat screen displays and tactical power sources. The major function of ETDL is to advance technology and:

a. Provide the soldier with the equipment to fight and win by inserting new technology into Army systems through continuing joint development with R&D centers, laboratories, and project managers.

b. Serve as a steward of the nations (world's) resources to meet the needs of the soldier.

c. Serve as a national center for electronic component research with on-site university industry participation.

1.2 Panel Composition

The review panel consisted of the following members:

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1.3 Panel Activities

The panel to review ETDL was constituted on 7 December 1987. (Appendix A) The first organization meeting was held in the Pentagon on 22 January 1988. The panel then conducted on site visits to ETDL in order to survey the laboratory facilities and to receive detailed laboratory organization and program briefings. The panel also contacted the primary users of ETDL's products and services in order to assess their usefulness to the technical community. A list of the organizations contacted is provided as appendix C. The panel also conducted a series of personal interviews with ETDL personnel ranging from technical management through support personnel in order to assess the motivation and morale of the ETDL personnel.

1.4 Acknowledgements

The panel greatly appreciated the open and cooperative spirit of the ETDL management, technical personnel and support staff in assisting in the conduct of the review. All personnel contacted were frank and open in discussions and responded professionally to detailed questions.

2.0 Summary of Findings

The Electronics Technology and Devices Laboratory is meeting its mission requirements for quality, productivity and relevancy. The following paragraphs summarize the key findings of this review.

- o What is the quality of the staff, facility and technical program of the Laboratory?

  - ETDL is maintaining a professional and support staff of high quality and appropriate diversity. Morale is good, and Laboratory management at the top and intermediate levels is providing strong and effective leadership.

  - The nature of ETDL's work requires a wide variety of sophisticated test equipment and facilities. The facilities seemed to be at the cutting edge of new technology. The panel was particularly impressed with the microelectronics equipment and facilities and with the new Pulse Power Testing Center. This new Center will require useful and strict attention to safety procedures to minimize hazards to personnel. Consideration should be given to establishing the position of safety officer reporting directly to the Director of ETDL to ensure that safety problems will be given the highest priority.

  - The Laboratory is in the process of consolidating most of its facilities in the Hexagon building and the nearby Pulse Power Center which should facilitate management and coordination of all activities.

  - The technical program is very diverse and includes many areas of rapid growth and change. With limited resources the Laboratory must be selective in choosing the technical areas of greatest importance and adjusting priorities from time to time. Most of the current technical programs appear to be of high quality.

  - ETDL has an impressive record of achievement awards for both the Laboratory and for individual members.

- o How productive is the laboratory in accomplishing its mission?

  - The panel was impressed by a number of products that had been successfully transitioned into fielded systems.

  - Continuing support by DOD of such programs as VHSIC and MIMIC attest to the perceived productivity of the Laboratory by other agencies.

- o How relevant is the Laboratory work to important Army problems?

  - The Laboratory appears to maintain close contact with Army-user agencies in order to anticipate needs and highlight the potential military usefulness of new technology.

  - As a result many of the current programs offer important leverage possibilities for improved systems, capabilities and/or cost reductions.

  - The ETDL requests for 6.3A level funding (advanced development to show system demonstration) are critical to continued success in meeting its mission statement.

3.0 Discussion of Findings

3.1 What is the Quality of the Staff, Facility and Technical Program?

3.1.a Staff

The ETDL Staff consists of approximately 313 personnel. The technical staff consists of 187 professionals (34 PHD's, 68 MS and 85 BS) and 34 technicians. The rest of the 91 personnel are administrative and clerical. The laboratory maintains an environment where personnel are encouraged to continue their education beyond the BS level. Cooperative and intern programs are actively supported to provide a continuing source of entry level professionals. In addition, ETDL participates with the National Science Foundation to provide an opportunity for graduate students to become residents at ETDL and conduct Army-oriented thesis research at no cost to the Army. During the period from 1 Jul 87 through 30 Apr 88, the turnover in professional personnel was a low four percent.

ETDL supports the principle of equal opportunity. As part of a management growth development program for women the Laboratory established 59 upward mobility/growth positions. This program enables female clerical personnel and others to bridge the gap to the management level through the position of Program Assistant, while taking management training courses at nearby colleges and universities. The ASB members conducted random interviews of minority and female ETDL personnel. A generally satisfactory EEO atmosphere exists at ETDL, and everyone interviewed agreed that management was supporting the EEO plan within financial and hiring constraints.

Considering the difficulty the Army has in competing with industry for quality technical personnel, ETDL appears to be doing quite well in maintaining the quality and distribution of technical degrees of its staff.

3.1.b Facilities

ETDL is located in the Hexagon Building and the Evans Area at Fort Monmouth, NJ. In addition, a state of the art Pulse Power Center located near the Hexagon is nearly completed. Once this facility is completed, it will provide the Army with a unique capability to conduct research, development, test and evaluation of high energy components and subsystems. This facility will become the focal point of high power testing for all three services, SDIO and private contractors requiring a test facility for high power electronic components. Considering the capabilities of the new pulse power center and the other expanding Laboratory facilities, a position of Laboratory safety officer reporting directly to the director of ETDL would focus attention on the unique nature of this facility. The establishment of this position would allow any potential safety issue to be immediately brought to the attention of the top management of ETDL for resolution. The current safety officer position is located in the Industrial Engineering and Development Division.

In addition to the Pulse Power Center, ETDL is actively pursuing a successful program of maintaining state of the art test facilities (electrical, environmental and diagnostic) for microcircuits, microwave/millimeter wave devices, flat panel displays and acoustic devices. The panel has concluded that ETDL is doing an outstanding job in acquiring and operating facilities and equipment at the cutting edge of new technology.

3.1.c The Technical Program

The ETDL management has developed a high quality balanced technical program that addresses the laboratory mission. The technical program is structured towards developing the electronic components needed for the next generation/notional systems. The selection of ETDL as the prime laboratory for the MIMIC and UHSIC programs indicates the high regard of the laboratory capabilities at the DoD level. In addition, ETDL has demonstrated a unique capability to respond to electronic component performance shortfalls uncovered in systems during their developmental test programs.

The laboratory has been recognized by the following awards, patents and other achievements:

- Six Department of Army Awards
  - One Army Meritorious Civilian Service
  - One Army Science Conference
  - Four Army R&D Achievement Awardees
- Two Secretary of Defense Productivity Excellence Awards
- One AMC Employee of the Year Award
- One Presidential Rank Award
- Fort Monmouth Handicapped Advisory Committee
  - Award of Achievement
- 31 Patents Issued (28 New Disclosures Processed, 31 New Patent Applications filed)
- 170 Journal/Conference Publications/Presentations
- NSF Joint Research Program
- Army "Award of Excellence" (1981, 1985, 1986)
- Army "Laboratory of the Year" (1980, 1983)
- AMC "Laboratory of the Year" (1986)

3.2 How Productive is the Laboratory in Accomplishing its Mission?

The Laboratory has an outstanding record of accomplishing its mission of transferring laboratory products to system developers and their contractors. Several examples of laboratory products successfully transitioned to system developers and their contractors are described below:

o An Improved Second-Generation Surface Acoustic Wave (SAW) processor for the MEDFLI. The MEDFLI is an airborne, broadband, phase interferometer Electronic Support Measures (ESM) Army system. The goal was to develop a SAW-based ESM/ELINT system that would provide a real-time identification and precision location of multiple, simultaneous radar threat emitters. The challenge was to implement a system that could operate over a wide intercept band with a 500 MHz processing bandwidth while operating in a signal environment where the signal density approaches millions of pulses per second with multiple time-coincident signals of different frequency content. The design goal was met by using a compressive receiver that uses a two-channel, SAW-based configuration. The system was shown to handle up to five multiple frequency, simultaneous signals and measure the angle-of-arrival and frequency as well as several other signal parameters. Although the prototype system was not optimized, it yielded a compact configuration of about four cubic feet that consumes relatively low power (on the order of 100 watts). The Scan rates of the receiver cover the 500 MHz bandwidth in 240 nanoseconds with 20 MHz resolution, with better than a 5 MHz frequency accuracy and a maximum angle error of less than 4°. ETDL was involved in the following areas: (1) demonstration of first-generation SAW processor; (2) incorporated SAW technology and system architecture into a EW-funded 6.3 ELINT receiver program; (3) evaluation of related CONFIDENTIAL technical proposals and assistance in technical program management; (4) demonstration of an improved second-generation SAW processor; (5) on-going technical interaction between system developers and contractor technical personnel.

o The Development of a Hybrid SAW Oscillator for Radiosondes. The Army Meteorological Data system was experiencing a frequency interference problem in the operation of radiosondes. An ETDL team was formed to address the issue and proposed a SAW stabilized oscillator approach to solve the interference problem. The design of the existing radiosonde was reviewed in the following order: (1) the frequency drift problem was analyzed; (2) various frequency stability technologies were assessed; (3) a design approach finalized; (4) a breadboard model based on the design assembled/evaluated and (5) then demonstrated in bench tests to the Army customer. Upon verification of the SAW technology, advanced models, were retrofitted in existing radiosondes and field-tested to confirm the sought after improvements under actual operating conditiions. Once the design was tested in the field, a contract was let to study ways to reduce the cost of the critical SAW components. This contract resulted in a reliable and repeatable SAW production facility. An in-house study of how to automate measurements of SAW component characteristics was also accomplished. The production facility was combined with automated testing approach developed by ETDL, resulting in a significant reduction in cost over the original radiosonde design. This achievement was recognized by the Secretary of Defense Productivity Excellence Award.

o Transitioning of Microcomputer - Compensated Crystal Oscillator Technology. There is a requirement for extremely accurate clocks for Army communications systems such as: The SINCGARS Fast Frequency Hop (FFH) upgrade, Regency Net, Objective High Frequency Radio (OHFR), Improved High Frequency Radio (IHFR); MILSTAR Hand-Held Module (HHM); and MILSTAR Improved Time Standard Module. The ETDL approach to satisfy this requirement is the microcomputer-compensated crystal oscillator (MCXO). Development models of the MCXO have demonstrated a three millisecond/day accuracy at all temperatures between -55° and +85° C, while consuming only 40 milliwatts. In contrast, the state of the art of conventional temperature-compensated oscillators remains at approximately 100 milliseconds/day. This breakthrough in accuracy was achieved through in-house research. The MCXO uses crystal resonators produced by ultra-clean processing technologies, low-stress mounting, and ceramic-flatpack-enclosed resonators with extremely low thermal hysteresis. The oscillator simultaneously excites two modes of operation in the resonator. These two modes of operation yield information about the resonator's temperature. Therefore, a very accurate frequency-temperature characteristic is obtained since the resonator is its own thermometer and has low hysteresis. A microcomputer then accurately computes the necessary correction to bring the output frequency to the desired nominal value.

Technical discussions of possible applications of the MCXO technology into product improvements of Army systems is on-going with system project offices and contractors.

o Transition of VHSIC into TOW, M1A1, Firefinder. Preliminary Technology Insertion workshops at ETDL in the early stages of the VHSIC program identified the TOW, M1A1 and the Firefinder as strong candidates for VHSIC Insertion. Subsequently, ETDL awarded contracts to Texas Instruments and Hughes for development of an Autotracker and M1A1 Fire Control Processor. The VHSIC devices developed for both the TOW Autotracker and the M1A1 Fire Control Processor took place under ETDL's Texas Instruments VHSIC phase 1 contract. Devices and applications studies were transitioned to the system contractors. The ETDL Firefinder VHSIC insertion program includes: review of requirements and specifications, the evaluation of proposals, the contract award, guidance and review of contractual efforts to develop the Firefinder VHSIC Signal Processor.

The Laboratory continues to stay abreast the mainstream of commercial technology in order to utilize the commercial technical data base to the greatest degree possible to support the defense needs of the country.

3.3 How Relevent is the Laboratory Work to Important Army Problems?

In conjunction with private industry, the laboratory has specified and developed sophisticated test equipment to analyze and diagnose microelectronic component manufacturing problems.

Several key programs of the laboratory that are specifically focused at meeting Army systems needs and surmounting technological barriers that limit the performance, reliability, or affordability of Army systems are:

o Millimeter wave devices, for more precise location and identification of targets through smoke, fog and battlefield obscurants.

o Millimeter wave wideband front ends of ELINT receivers as well as microwave and millimeter wave GaAs devices for compact, secure, reliable data links, for use in C^3 and navigation systems.

o Affordable and militarily acceptable microwave and millimeter-wave monolithic integrated circuits (MIMIC) for the transmission, reception and processing of analog signals by smart munitions, phased arrays, multi-beam antennas and real time channelizers.

o High speed and large scale signal processing (VHSIC, VLSI) devices to provide a broad range of capabilities for tactical weapons and C^3 systems.

o Lightweight, high efficiency portable power supplies for designator, night vision, and communication-electronics (C-E) systems.

o Very high pulse power generators and pulse power conditioning components for directed energy weapons, laser designators and kinetic energy weapons.

o Surface acoustic wave (SAW) devices to reduce co-site radio interference, to detect remotely chemical concentrations, and to maintain low phase noise oscillator stability in missile environments.

o Ultra-stable crystal oscillators and clocks for tactical radios and other C^3 systems to facilitate fast frequency hopping and/or high speed pseudo-noise sequencing for ECM devices.

o Techniques (VHSIC Hardware Description Language -- VHDL) to facilitate the replacement of old and obsolete microelectronic parts with modern technology.

In addition, the ASB members contacted many of the ETDL customers (Appendix C) in order to assess the usefulness of the Laboratory product. In general, both the government and industry users of ETDL products are highly complimentary of the Laboratory. A summary of both industry and government users comments follow:

- o The Laboratory is very effective in accomplishing its mission.
- o The staff is responsive to solving customer problems.
- o The technical capability of the ETDL staff is excellent.
- o The personnel are easy to work with and show initiative in attacking the problem at hand.
- o There is concern about the relatively low level of research funding of the laboratory and the stability of some programs.

This Laboratory has an enviable record of developing timely and impressive R&D investment strategies that have provided significant improvements to Army systems.

The ETDL requests for 6.3A level funding (advanced development to show system demonstration) are critical to continued success in meeting its mission statement. Some of the devices in development require demonstration at the 6.3 level in order for them to be favorably considered for insertion into Army systems.

Appendix A

The Electronic Technology and Devices Laboratory Mission and Interfaces

LABCOM

The U.S. Army Laboratory Command (LABCOM) is intended to be AMC's "Corporate Technology Center". It is headquartered in Adelphi MD in the same facility with the Harry Diamond Laboratory. Its commander, Brig Gen Malcolm O'Neill, is "dual-hatted" in that he not only commands LABCOM but he is also AMC's Deputy Commander for Research and Development.

Organization and Mission

LABCOM has direct control over seven Army Laboratories plus the Army Research Office (ARO). This is shown on the attached organization chart. Some of these labs are very large and others relatively small. The Electronic Technology and Devices Lab (ETDL) is of medium size, but has a very broad mission from a technology point of view. LABCOM has two major missions. The first is to manage the AMC-wide Tech Base program. Primarily this means that LABCOM should plan, prioritize, and allocate R & D funds in the 6.1, 6.2 and 6.3 category. Note that the LABCOM commander in his other role as AMC deputy has control over these funds for all of the laboratories and RD & E centers within the Army Materiel Command.

The second mission is to manage the Corporate Technology Laboratories, that is, the laboratories directly under LABCOM command. This latter is a system of approximately 4,000 to 6,000 people with an operating budget of $600 - 9 million dollars per year. In order to perform this mission the LABCOM headquarters is organized as shown on the attached chart. Of particular concern

to subordinate laboratories such as ETDL is the technology planning and management function. This includes such things as long-range planning, program formulation, budgeting and execution oversight. It is responsible for establishing policies and procedures for operations and management of the corporate labs as well as information transfer and analysis and support in general. Apparently LABCOM also has a mission to restructure the corporate lab as necessary to create a critical mass in army-unique technologies.

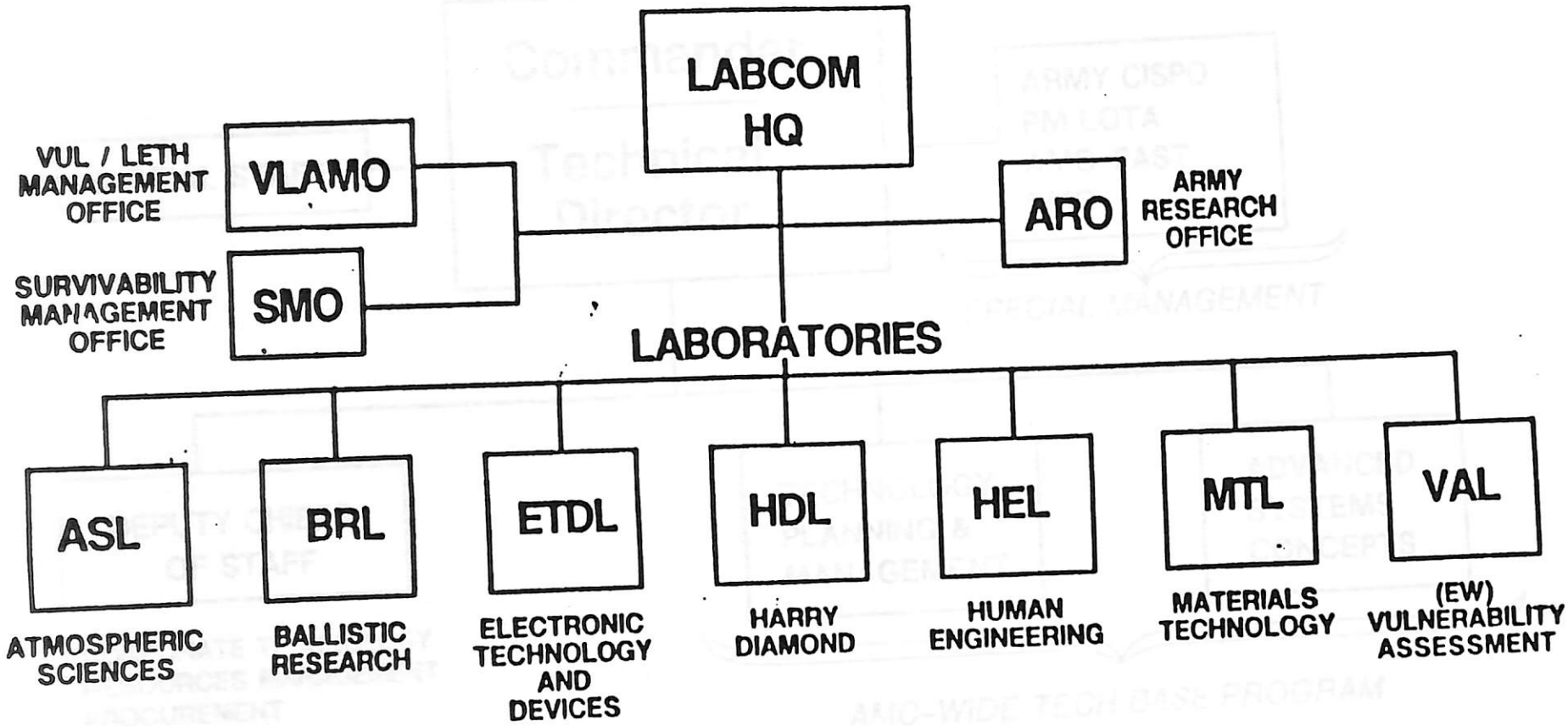
In discussing the LABCOM interface with ETDL personnel it appears that all budget planning and allocation funnels through this headquarters as well as AMC Headquarters and that LABCOM generally performs its role well as advocate for the corporate labs. On the other hand, it is not clear that LABCOM is able or willing to do the difficult job of restructuring (organizationally and personnel-quota-wise) these labs under it's control in response to quality and needs considerations. The ad hoc sub group was not able to go deeply enough into this matter to make a definitive conclusion.

There appears to be a very close liaison between key personnel at ETDL and appropriate members of the LABCOM staff and there is also much direct contact with R & D personnel at AMC Headquarters. There seems to be a healthy respect and regard for personnel at LABCOM.

It should also be noted that this LABCOM structure is relatively new and is still evolving.

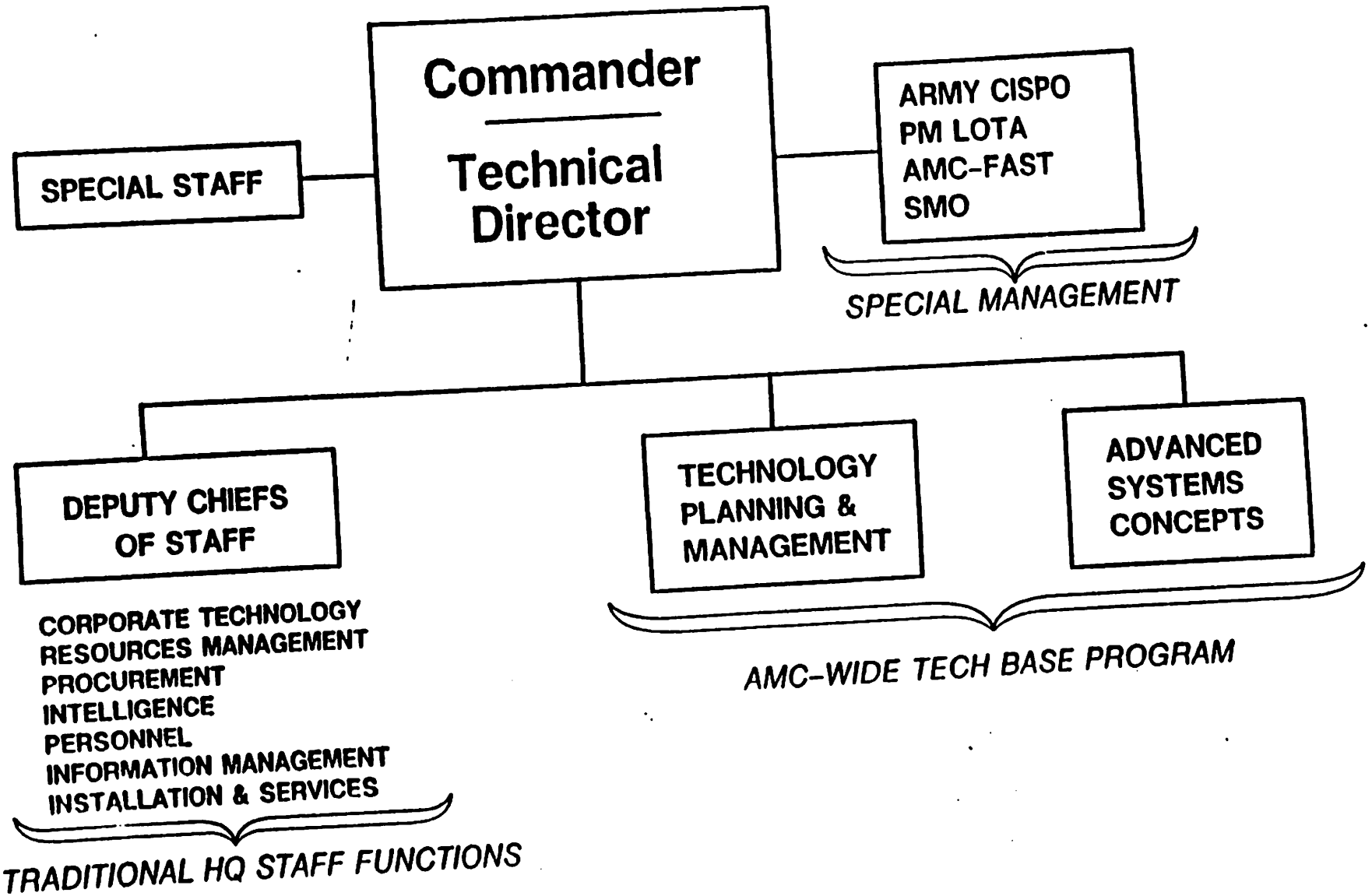
LABCOM: AMC'S "CORPORATE TECHNOLOGY CENTER"

US ARMY LABORATORY COMMAND



HEADQUARTERS ORGANIZATION

US ARMY
LABORATORY COMMAND



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Appendix B

Tasking Letter

OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, DC 20310-0103

7 DEC 1987

Mr. Gilbert F. Decker
Chair, Army Science Board
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Dear Mr. Decker:

A number of recent studies of Federal Laboratories have pointed out the importance of external effectiveness reviews as a means of assuring their continuing excellence. Accordingly, I ask that you appoint an Army Science Board panel of four to eight members to conduct an effectiveness review of the Electronic Technology and Devices Laboratory, Fort Monmouth, New Jersey. The panel should provide independent observations on potential and actual performance of the laboratory, including professional judgment on the cause of deficiencies, if any. A proposed framework for the assessment is enclosed. Specifically, the panel should address the following five questions:

a. What is the quality of staff, facility and technical programs?

b. How productive is the lab in accomplishing its mission?

c. How relevant is the lab's work to important Army problems?

d. How can we improve the assessment methodology and procedures?

e. What are the lessons learned from conducting the review?

Lieutenant General Jerry M. Bunyard, Deputy Commanding General, United States Army Materiel Command, is the sponsor. Brigadier General Richard D. Beltson, Deputy for Technology and Assessments, Office of the Secretary Army (RDA), will serve as the OASA(RDA) Cognizant Deputy. Mr. Robert J. Redwinski, U.S. Army Materiel Systems Analysis Activity, will serve as the DA Staff Assistant.

It is not anticipated that your inquiry will go into any "particular matters" within the meaning of Section 208 of Title 18, United States Code.

The panel should begin as soon as possible and complete its review by 30 May 1988.

Sincerely,

J. R. Sculley
Assistant Secretary of the Army
(Research, Development and Acquisition)

Enclosure

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* THE PARTICIPANTS LIST WAS SUBSEQUENTY REVISED TO THE PANEL COMPOSITION PROVIDED IN SECTION 1.2, ON PAGE 1 IN THE REPORT.

Washington, D.C.

GOALS AND OBJECTIVES FOR DEPARTMENT OF DEFENSE RESEARCH AND DEVELOPMENT LABORATORIES

The Department of Defense laboratories exist to achieve—in cooperation with universities and industry—a level of technological leadership that will enable the United States to develop, acquire, and maintain military capabilities needed for national security.

MISSION

- Ensure the maintenance and improvement of national competence in technology areas essential to military needs
- Avoid technological surprise and ensure technological innovation.
- Maintain a continuity of effort, free from excessive commercialization pressure, directed toward the conception and evolution of advanced military materiel and support technologies.
- Pursue technology initiatives through the planning, programming, and budgeting process, allocate work among private sector organizations and government elements.
- Act as principal agents in maintaining the technological base of the Department of Defense
- Provide materiel acquisition and operating system support.
- Have available a fast-reaction capability to solve critical, immediate technical problems that arise when unexpected operational situations are encountered.
- Stimulate the use of demonstrations and prototypes to mature and exploit U.S. and allied technologies
- Carry out activities having high technological risk or requiring intensive resource investment not available from the private sector.
- Interface with the worldwide scientific community; provide support to other governmental agencies

OPERATIONS

- Respond to national defense needs by undertaking actions to
  - Achieve timely improvements in military systems and develop techniques for increasing their effectiveness
  - Reduce manpower and skill constraints on materiel performance
  - Lower materiel production, operation, and support costs
  - Extend life of operational systems
- Continue interactive user-developer interfacing to
  - Achieve greater sensitivity to potential combat requirements and operating environments
  - Integrate technological objectives with materiel readiness, modernization, and sustainability requirements
  - Evolve effective balance between technology push and requirements pull
- Continue a vigorous partnership with industry and the academic community.
- Distribute efforts appropriately across short-, mid-, and long-term horizons.
- Participate actively in the overall Defense planning process

MANAGEMENT

- Provide laboratory managers with the responsibility, authority, and flexibility to manage laboratories and technical programs through use of broad guidelines and without overlapping controls.
- Ensure competency of Personnel
  - Recognize clearly that the most valuable resource of the laboratories is the capability, skill, and creativity of their personnel
  - Provide for personnel stability, challenging work, and meaningful incentives
  - Provide for equal opportunity for career development, training, promotion, recognition and reward
- Upgrade Facilities and Equipment
  - Remove limitations which constrain modernization of laboratories
  - Promote productivity, energy efficiency, and cost avoidance through policies which provide for modern facilities and equipment
  - Base replacement policies on practices that befit the business venture nature of research and development activities.
- Provide effective procedures for Procurement and Acquisition
  - Provide laboratories with the authority and capability to make procurements and acquisitions in a timely and efficient manner
  - Ensure technical excellence in contractor performance
- Achieve continuing Assessment and Accountability

The Office of the Secretary of Defense and the Military Departments are jointly responsible for establishing policies and procedures conducive to the continuing vitality of the laboratories. Accordingly, periodic evaluations will be conducted to assess the health of the laboratories, the quality and quantity of their contributions, and their performance against the public's legitimate expectations of efficient and effective use of personnel and financial resources.

PROPOSED FRAMEWORK FOR ASSESSMENT

QUESTION 1. What is the quality of the staff, facility and technical progra of the lab?

1. Balance of background - i.e., adequacy of the distribution and mix of degrees based on relevance to the lab's mission.

2. Currency of degrees and/or other technical training of technical and management staff.

3. Quality, scope and innovativeness of training programs.

4. Peer recognition of technical personnel within government and private sectors.

5. Initiatives to maintain staff technical competence in contract heavy operations, i.e., the ability to retain smart buyer posture.

6. Staff stability and effectivity of recruiting initiatives.

7. Adequacy of physical plant and other physical resources - plans and initiatives for upgrade.

8. Degree to which automation and other leading edge tools and techniques have been introduced into the workplace.

9. Assess technical program balance within context of mission responsibilities.

10. Degree to which technology program is forward looking, i.e., demonstrates willingness to assume technological risk to attain marked advances.

11. Relevance of technology base efforts to mission responsibilities.

12. Reputation of lab within Army, DOD and industrial complex.

QUESTION 2. How productive is the lab in accomplishing its mission?

1. Relevant patents granted (not just applied for).

2. Outside awards and other significant recognition accorded labs and/or personnel.

3. Relevant technical papers/reports published (subjected to independent peer review).

4. Responsiveness of lab, i.e., providing solutions to unanticipated problems in developmental or fielded systems and/or newly identified threats.

5. New concepts successfully transitioned to significant materiel development/improvement programs.

6. Integration of external technology capability to address lab responsibilities.

7. Manpower utilization/cost per professional manyear.

8. Army's present materiel/system/component capability in the laboratory's area of responsibility versus that of our adversaries.

QUESTION 3. How relevant is the lab's work to important Army problems?

1. Relationship of technology programs to deficiencies and those identified in other materiel needs and requirements documents (Army 21, C^2SPR, AC^2MP, etc.).

2. Degree of interface with the field user.

3. Components/subsystems/systems fielded and supported (past five years).

4. Army/DOD customer programs (lab services or hardware provided).

5. Importance of maintaining an in-house capability (versus existing industry/university sources).

Appendix C

Organizations contacted

ETDL CLIENT/CUSTOMER CONTACTS

EIC Co.
111 Downey Street
Norwood, MA 02062

Colorado Crystal Corp
2302 W. 8th Street
Loveland, CO 80537

Hughes EDD
3150 W. Lomita Blvd
Torrance, CA 90509

Dept of EE & Computer Science
PINY
333 Jay Street
Brooklyn, NY 11201

Research Triangle Institute
PO Box 12194
Research Triangle Park, NC 27709

PM-Water TROSCOM
Fort Lee Billeting Branch
PO Box 12194
Fort Lee, VA 23801

U.S. Army Missile Command
AMSMI-QA-QT-RT
Redstone Arsenal, AL

PM PATRIOT Missile System
AMCTM-PA-JTMD-W
Redstone Arsenal
Huntsville, AL 35898-5620

DNA
6801 Telegraph Road
Alexandria, VA

EW/RSTA
Fort Monmouth, NJ 07703-5000

Stonehart Associates
PO Box 1220
Madison, CT 06443

PM SINCGARS
Fort Monmouth, NJ 07703-5000

TRW
One Space Park
Redondo Beach, CA 90278

Solid-State Device Research
Scientific Rsch Associates
PO Box 498
Glastonbury, CT 06033

University of Michigan
CS Building, Rm 2228EE
1301 Beal Avenue
Ann Arbor, MI 41809-2122

University of Illinois
Coordinated Science Lab
1101 W. Springfield Avenue
Urbana, IL 61801

IBM
9500 Godwin Drive
Manassas, VA 22110

Dept of Physics
Brooklyn College CUNY
Bedford Avenue & Avenue H
Brooklyn, NY 11210

PM, Test Measurement & Diag Equip
AMCPM-TMDE-LT
Fort Monmouth, NJ 07703-5000

SDIO Hi Power Thyratron
Texas Tech
Lubbock, TX 79409

VISTA Technologies
Gould Research Center
50 Gould Center
Rolling Meadows, IL 60008

Defense Logistics Agency
DESC-E
Dayton, OH

Dept of Chemistry
NJ Institute of Technology
323 Martin Luther Jr. Blvd
Newark, NJ 07102