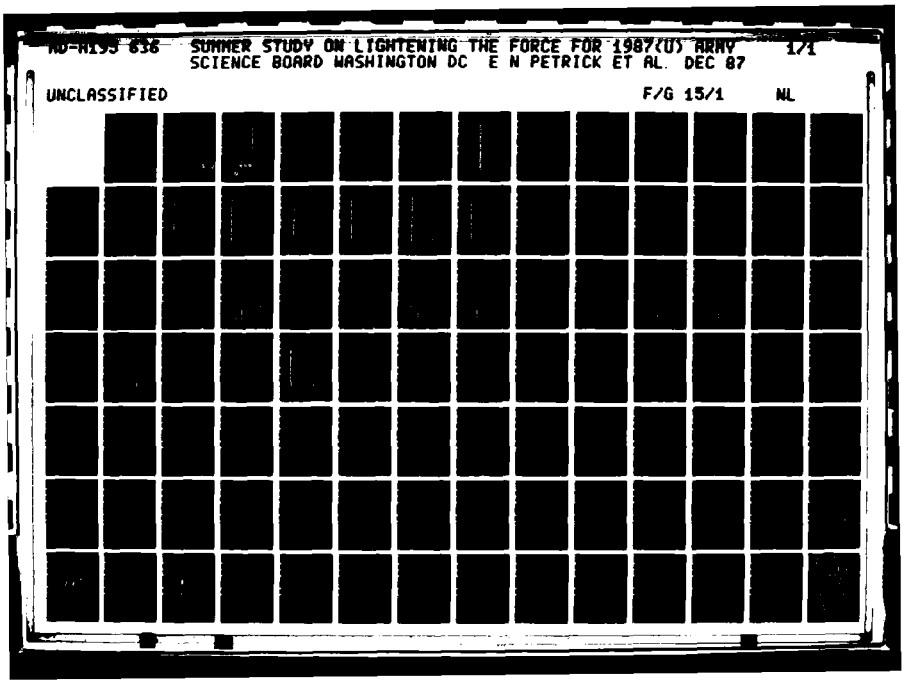
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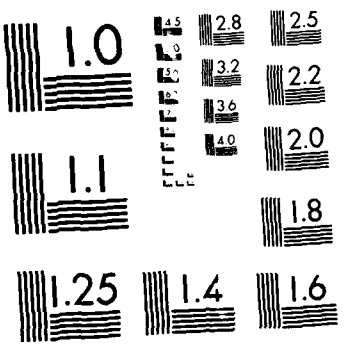
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24 MAY 1988

AD-A195 636

MEMORANDUM FOR DISTRIBUTION

SUBJECT: Final Report of the Army Science Board (ASB) 1987 Summer Study (SS) on "Lightening the Force"

Attached is the Final Report of the 1987 ASB SS on "Lightening the Force," dated December 1987.

The study, co-sponsored by the Commander, TRADOC and the Deputy Chief of Staff for Research, Development and Acquistion focuses on the meaning of lightening the force and technologies that could lighten the force while maintaining combat effectiveness. The Panel made recommendations for a uniform Army definition, a focal point to oversee and prioritize the efforts, lighter man-portable electronic gear, reduced vehicular fuel consumptions, greater use of smart weapons, and the establishment of a program to exploit long-term technologies.

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

Attachment

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DEPARTMENT OF THE ARMY
ASSISTANT SECRETARY OF THE ARMY
RESEARCH, DEVELOPMENT AND ACQUISITION
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ARMY SCIENCE BOARD

FINAL REPORT OF THE 1987 SUMMER STUDY

ON

LIGHTENING THE FORCE

DECEMBER 1987

Approved for public release;
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report addresses the findings, conclusions and recommendations of the Army Science Board Summer Study on Lightening the Force. The study focuses on the meaning of lightening the force and technologies that could lighten the force while maintaining combat effectiveness. The Panel made recommendations for: a uniform Army definition, a focal point to oversee and prioritize the efforts, lighter man-portable electronic gear, reduced vehicular fuel consumption, greater use of smart weapons, and establishment of a program to exploit long-term technologies.

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LIGHTENING THE FORCE (LTF)

1987 SUMMER STUDY
ARMY SCIENCE BOARD

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EXECUTIVE SUMMARY

The Army initiated an active program to lighten the forces when the Chief of Staff of the Army provided a descriptive white paper to the Congress in 1980. The light force initiatives, some completed and some in process, include:

- Creation of five new light infantry divisions of 10,000-soldier strength: 7th Infantry Division (ID) (Light) Ft. Ord, CA; 25th ID (Light), Schofield Barracks, HI; 10th Mountain Division (Light Infantry), Ft. Drum, NY and Ft. Benning, GA; 6th ID (Light), Ft. Richardson and Ft. Wainwright, AL; 29th ID (Light), Ft. Belvoir, VA.

- Restructuring of the 82nd Airborne Division and the 101st Airborne Division (Air Assault)

- Strengthening and augmenting Rangers and Special Operations Forces.

The original objective was to reduce the time and the number of aircraft sorties required for the deployment of a light division.

At the request of the Commanding General of the US Army Training and Doctrine Command (TRADOC) and of the Deputy Chief of Staff for Research, Development and Acquisition (DCSRDA), the Assistant Secretary of the Army (Research, Development and Acquisition) established an Army Science Board (ASB) Summer Study Panel to re-examine the Army's efforts and in particular the various concepts, pacing technologies and systems worth pursuing in lightening the land combat power force.

The Panel undertook the study based on three implicit principles, although not directly stated in the Terms of Reference, which focused on the technologies applicable to lightening land power. The principles are:

- By definition, the Army Force is the <u>total</u> Army; therefore, lightening efforts pertain not only to initial deployment, but to force sustainment without degradation of fighting capabilities.

- Technology shall be considered in three timeframes: Near-term -- both technology and engineering are in hand, ready for application; Mid-term -- technology known, further engineering development required; and Far-term -- neither technology nor engineering are fully in hand, but a concept is envisioned for application in the Army of the future.

- Recommendations shall be specific and shall be limited to one or two in each technological timeframe, ranging from immediate implementation to laying the groundwork for the coming generation of an unconventional high technology Army.

Prior to the two-week Summer Study at Ft. Monroe, the Panel and subpanels held 15 meetings and site visits including DA Headquarters Staff elements, TRADOC Schools, Army Materiel Command (AMC) Research, Development & Engineering Centers/Labs, Defense Advanced Research Projects Agency (DARPA) the 4th, 7th, 9th ID and I Corps, as well as discussions with several active and retired key Army Commanders. Without exception the cooperation of the various Army elements was excellent and the participants exhibited a keen interest in the purpose and progress of the study.

The concept of "lightening" has been accepted and supported within the Army. Specific supporting programs have been undertaken by a number of commands and agencies including AMC and TRADOC. These efforts have focused principally on weight reduction, but in many cases the relationship to the original objective is not clear. This is due, in some measure, to the lack of an effective mechanism of analytical tradeoffs and of an organizational overview which treats "lightening the force" (LTF) from a total Army perspective.

The Panel considered six principal issues:

- The understanding within the Army of the term "LTF"
- The integration and discipline being applied to lightening efforts
- The application of near-term technology to lighten the Army's electronic gear
- The relationship between reduced fuel consumption and a lighter Army
- The application of mid-term technology, specifically target discrimination technology (smart weapons), to reduce overall ammunition requirements
- The pacing long-term technologies for the next generation Army and definition of a weapon system to focus research, development and doctrine.

As a result of its deliberations, the Panel recommends that the Army redefine the objective in lightening the force and then focus the ongoing effort, specifically:

- Adopt and articulate a uniform Army definition, with an underlying requirement that all lightening efforts maintain or improve total force effectiveness.

- Headquarters, Department of Army (HQ DA) designate a focal point to overview and prioritize the effort.

- Identify man-portable electronic gear that can be significantly lightened with today's technology, and stop the proliferation of uniquely (and unnecessarily) designed components, such as specialized batteries.

- Dramatically lighten the Army's sustainment requirements by establishing a major strategic goal to reduce <u>total</u> vehicular fuel consumption by 50 per cent.

- Designate a single manager for the target discrimination technology program encompassing doctrine, operations and technology, to ensure achievement of the significant ammunition-saving potential of smart weapons.

- Establish a separately-managed program to focus the pacing technologies defined in this report which can usher in the next Army era beyond today's conventional weaponry. An all-electric mobile weapon system is recommended as the precursor of a future generation Electric Battalion utilizing electrically-powered mobility and weaponry.

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TERMS OF REFERENCE

- WHAT TECHNOLOGIES ARE AVAILABLE OR COULD BE DEVELOPED TO LIGHTEN THE FORCE?
- ASSESS THE PRIORITIES, RISKS, AND PAYOFFS OF THE TECHNOLOGIES . . . LOW AND MID-TO-HIGH INTENSITY CONFLICTS . . . HEAVY AND LIGHT DIVISIONS.
- WHAT ARE THE PACING TECHNOLOGIES, . . . WHAT CONCEPTS/ TECHNOLOGIES/SYSTEMS SHOULD BE EMPHASIZED?
- HOW CAN THE ARMY BEST ENSURE THAT THOSE TECHNOLOGIES ARE NOT ONLY CAPTURED BUT INTEGRATED AND COST EFFECTIVELY ACQUIRED?
- ASSESS THE ARMY'S CAPABILITY TO MODEL AND TEST LOW INTENSITY, FORCE-ON-FORCE CONFLICTS.

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, DC 20310-0103

8 JAN 1987

Dr. Irene C. Peden
8752 Sand Point Way, NE
Seattle, WA 98115

Dear Dr. Peden:

Please appoint an Army Science Board Summer Study Panel of 10-15 members to examine Lightening the Force.

Historically, the Army's doctrine, force structure, and equipment initiatives have focused on defeating Soviet threat forces in mid-to-high intensity environments. This focus has resulted in the evolution of our heavy force to the current Army of Excellence structure. It is likely that we may have to defeat a larger force with a smaller force; Army doctrine is designed to deal with this type of encounter.

With regard to utillization of lighter forces, increased terrorism and instability in Third World countries, and to some extent in developed countries, have brought about changes in U.S. requirements globally. The creation of the Light Infantry Division provides the National Command Authority an improved capability to project ground combat power rapidly worldwide. This capability offers a means of deterring conflict or of further escalation of a conflict. A requirement for deployment to different parts of the world is probable and if there is conflict it will be necessary to deploy forces sufficient to win. A need exists to lighten the land combat power force.

There has been progress in the R&D community, e.g., composite materials for lightening vehicle weight and the development of a lightweight cannon, but there should be a re-examination of the many other concepts/technologies/systems worth pursuing. With regard to application of these technologies, a number of questions need examination. Consideration of the current situation and projection of future Army needs leads to the following Terms of Reference for an Army Science Board Study on Lightening the Force:

- What technologies are available or could be developed to lighten the force in the areas of: (a) equipment, (b) mobility (inter and intra-theater), (c) armament, (d) clothing, and (e) sustainment?

- Assess the priorities, risks and payoffs of these technologies in low and mid-to-high intensity conflicts where applicable for both the heavy and light divisions of the Army.

- What are the pacing technologies for lightening Land Power? What concepts/technologies/systems should be emphasized to enhance the projection of lightened ground combat power? What realistic objectives can be identified to decrease the mass while increasing the lethality of the ground combat force?

- How can the Army best ensure that these technologies are not only captured but integrated and cost-effectively acquired?

- Can a systems approach be applied to lightening the force (e.g., what equipment is on the battlefield but does not contribute?).

- Assess the Army's capability to model and test low-intensity, force-on-force conflicts realistically considering the many independent variables (e.g., geopolitical considerations). Identify alternative ways to improve that capability.

General Carl E. Vuono, CG, US Army Training and Doctrine Command (TRADOC), and Lieutenant General Louis C. Wagner, Jr., Deputy Chief of Staff for Research, Development and Acquisition, Headquarters, Department of the Army are Co-Sponsors of the study. MG George Krausz, Deputy Chief of Staff Combat Development (DCSCD), HQ TRADOC, and Mr. George Singley, Office Deputy Chief of Staff for Research, Development and Acquisition (ODCSRDA) will serve as the Senior Advisors. Mr. John Appel, ODCSRDA (DAMA-ART), will serve as the DA Staff Assistant for the study. Colonel Robert E. Brown, Director of Space and Technology Directorate, HQ TRADOC, will serve as the TRADOC Staff Assistant for the study.

The study should begin immediately and conclude at the report writing and summarization session 19-30 July 1987 at HQ TRADOC, Fort Monroe, VA.

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.

Sincerely,

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

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MEETINGS AND SITE VISITS

PENTAGON	15-16 JANUARY 1987	PLENARY SESSION
FT MONROE	19-20 FEBRUARY 1987	BRIEFING BY TRADOC SCHOOLS
PENTAGON	18-19 MARCH 1987	BRIEFING BY AMC
ARLINGTON, VA	20 MARCH 1987	BRIEFING BY DARPA
FT ORD	28 APRIL 1987	MEETING WITH 7TH ID (LIGHT)
FT CARSON	30 APRIL 1987	MEETING WITH 4TH ID (MECH)
FT LEE	18 MAY 1987	BRIEFINGS BY LOG CENTER
FT EUSTIS	18 MAY 1987	BRIEFINGS BY TRANSPORTATION SCHOOL
PENTAGON	19 MAY 1987	MEETING WITH OFFICE OF THE DEPUTY CHIEF OF STAFF FOR LOGISTICS
FT LEWIS	19-20 MAY 1987	MEETING WITH I CORPS AND 9TH ID (MOTORIZED)
ARLINGTON, VA	19-20 MAY 1987	TECHNOLOGY SUBGROUP MEETING
ARLINGTON, VA	17-18 JUNE 1987	PLENARY SESSION
PENTAGON	30 JUNE 1987	EXECUTIVE SESSION
FT MONROE, VA	21 JULY 1987	AIRLIFT & SEALIFT/SMART WEAPONS
FT MONROE, VA	22, 28 JULY 1987	MEETING WITH TRADOC ON ARMORED FAMILY OF VEHICLES

SOME INDIVIDUAL VISITS/DISCUSSIONS

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MG W.A. SHOFFNER

MG G. KRAUSZ

MG T. FOLEY

MR. DON FREDERICKSON, OSD

HISTORY OF ARMY'S LIGHT FORCES EFFORT

- CHIEF OF STAFF, ARMY (CSA) WHITE PAPER (1980)
- HIGH TECHNOLOGY TEST BED (HTTB) ESTABLISHED (1981); REDESIGNATED AS ARMY DEVELOPMENT EMPLOYMENT AGENCY (ADEA) (1983)
- CSA WHITE PAPER ON LIDS (1984)
- RESTRUCTURING OF 82ND AND 101ST AIRBORNE DIVISIONS
- CREATION OF FIVE LIDS (ONGOING)
- ARMY MATERIEL COMMAND (AMC) TECHNOLOGY EFFORTS/CDR'S POLICY STATEMENT (1986)
- ARMY SCIENCE BOARD (ASB) SUMMER STUDY (1987)

ISSUES FOR LIGHTENING THE FORCE

1. DEFINITION
2. INTEGRATION & DISCIPLINE
3. ELECTRONIC GEAR
4. FUEL CONSUMPTION
5. TARGET DISCRIMINATION TECHNOLOGY
6. LONG TERM TECHNOLOGIES: ALL-ELECTRICAL WEAPONS SYSTEMS

ISSUE 1: THE ARMY HAS NOT ADEQUATELY DEFINED THE CONCEPT NOR SPECIFIED THE OBJECTIVE FOR LTF

FINDINGS:

- LTF HAS DIFFERENT MEANINGS WITHIN THE ARMY
- IN THE CONTEXT OF TOTAL FORCE EFFECTIVENESS, INCLUDING THE LIGHT DIVISION INITIATIVE, THE ARMY HAS NOT LIGHTENED THE FORCE
- TRANSPORTABILITY, INCLUDING SUSTAINABILITY, AND AGILITY ARE KEY OBJECTIVES FOR LTF EFFORTS
  - WEIGHT ALONE IS NOT AN ADEQUATE MEASURE
  - PETROLEM, OIL, AND LUBRICANT CONSUMPTION AND AMMUNITION CONSUMPTION ARE MAJOR TARGETS OF OPPORTUNITY

ISSUE 1: THE ARMY HAS NOT ADEQUATELY DEFINED THE CONCEPT NOR SPECIFIED THE OBJECTIVE FOR LTF

RECOMMENDATIONS:

- **THE ARMY ADOPT A UNIFORM DEFINITION FOR "LIGHTENING THE FORCE" FOR EXAMPLE:**

  "ACHIEVING A REDUCTION IN WEIGHT, CUBE, OR SQUARE TO IMPROVE:

  - **FORCE TRANSPORTABILITY, INCLUDING SUSTAINABILITY AND/OR**
  - **FORCE AGILITY**

  WHILE MAINTAINING OR IMPROVING TOTAL FORCE EFFECTIVENESS"

- **ARMY MANAGEMENT'S EVALUATION CRITERION SHOULD BE TOTAL FORCE EFFECTIVENESS**

Discussion (Issue 1):

"LTF" has different meanings to different elements of the Army. This is apparent as one reviews the LTF objectives and initiatives described by the TRADOC Schools (see Appendix I) and by the AMC Labs/R&D Centers (see Appendix F). To some, LTF literally means only the reduction of mass or weight. To others it means lightening the soldier's load, and to still others, it means changing the organization. As a result of the lack of a commonly understood objective and definition, the effort is diffused and without a prioritization of effort. The Panel's understanding is that the original objective expressed in 1980 was to reduce the number of aircraft sorties required for the initial deployment of an infantry division.

In the context of the Army's objectives to deploy a force expeditiously outside the United States, either to deter a conflict or bring it to a successful conclusion should deterrence fail, mass and particularly the mass of the initially deployed force (without its sustaining support) is not a sufficient measure of "LTF". LTF proposals must be evaluated in terms of total force effectiveness in accomplishing the mission which is scenario dependent. If one examines a corps' size force operation which includes the sustainment and support that must be provided to the cutting edge in the initially deployed divisions, it is not evident that lightening has occurred. This lack of total force lightening was illustrated in the Panel's examination of an Army scenario involving projected deployment weights of two different five-division task forces, one with all-heavy and the other with light-plus-heavy divisions (see Appendix A).

Reduced transportability is a key criterion but weight along is not an adequate measure for transportability; frequently cube or area are the limiting factors. At a sustaining supply consumption rate of 3,050 tons per day, a heavy division consumes its own weight each 27 days or less. Fifty per cent of this consumption is in POL (fuel) and 40 per cent in ammunition. Based on data received from the 7th ID, a light ID consumes its own weight in 19 days of combat. Sustainment is a key issue and, therefore, fuel and ammunition consumption are major targets of opportunity for reducing the transportability problem in "LTF".

A second criterion for lightening is force agility, the ability of friendly forces to act faster than the enemy. Force agility has both a physical and mental aspect when viewed from the commander's perspective. The physical aspects of agility involve preparing for battle, moving to position prior to engagement, striking enemy forces, transitioning to be ready to begin the cycle again, while minimizing vulnerability to enemy actions. The mental aspects of agility include visualizing the objective, conceptualizing the battle, seeing and understanding the battlefield, making decisions, and directing the fight.

The Panel deliberated at some length on an appropriate objective for lightening today's Army and developed the definition presented in the foregoing briefing chart. It is appropriate for the purposes of this study, but rather than accepting it carte blanche, the Army needs to conduct a deliberate reexamination of the purposes and objectives of lightening today's force, develop or adopt a suitable definition and articulate it to the Army community. If it is determined that the original objective has been met and that no new purpose is evident, the term "LTF" should be dropped from the Army lexicon.

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ISSUE 2: THE ARMY'S LTF EFFORTS REQUIRE AN IMPROVED SYSTEM INTEGRATION AND DESIGN DISCIPLINE FOR NEW ACQUISITIONS

FINDINGS:

- THE ARMY HAS TAKEN SOME POSITIVE EFFORTS TO IMPROVE SYSTEM INTEGRATION:
  - COMBINED ARMS MISSION AREA ANALYSIS
  - "LIGHTENING THE SOLDIER'S LOAD"
- THE INTEGRATING CENTERS WITHIN TRADOC ARE NOT PROVIDING ADEQUATE INTEGRATION AND PRIORITIZATION OF LTF PROGRAMS
- LITTLE, IF ANY, SYSTEMS APPROACH HAS BEEN APPLIED ACROSS THE TOTAL ARMY TOWARD EVALUATING LTF EFFORTS. EMPHASIS AND DISCIPLINE ARE LACKING

ISSUE 2: THE ARMY'S LTF EFFORTS REQUIRE AN IMPROVED SYSTEM INTEGRATION AND DESIGN DISCIPLINE FOR NEW ACQUISITIONS

RECOMMENDATIONS:

- HQDA DESIGNATE A FOCAL POINT ACROSS THE ARMY AND ENFORCE LTF DISCIPLINE
- HQ, TRADOC BE THE INTEGRATOR RATHER THAN A SUPPORTER OF INDIVIDUAL BRANCH INTERESTS

Discussion (Issue 2):

The Army has made progress in integrating elements of different mission areas and functions (e.g., better consideration of logistics in development of combined arms doctrine). In the combined arms area the Army has taken steps to utilize a combined arms mission area analysis (MAA) so it can better evaluate the tradeoffs and alternatives available across mission areas addressed by the individual schools and centers. The Army Staff has applied a systems approach to "Lightening the Soldier's Load". The latter has been a fruitful effort with excellent results, and should be conducted in other areas as well. However, in the larger context of LTF, such dedicated staff efforts lack management guidance from senior Army leadership.

The combined arms MAA is not designed in the early stages to cover potential support variables, such as variations in maintenance strategies, or alternative support organizations, or other means for providing elements of logistics support. Consideration of such support variables in evaluating future force structures (and potential variations in doctrine) needs to be included in Army analytic efforts to enable a better evaluation of total force choices and LTF efforts.

The Panel, in reviewing Army activities related to LTF, has not been able to determine any sense of prioritization by the Army among the "lightening" efforts or the correlation of those efforts with other Army programs. Of equal or greater importance, no focal points were found in the DA Staff, TRADOC or AMC for analyzing and evaluating the potential total force contributions of alternative proposals for LTF. In fact, during the Panel's review, some elements of the Army appeared as a collection of semi-independent branches and functional area specialties with each one believing (and arguing for purposes of resource allocation) that its contribution to the overall Army mission is equal to or more important than any other. The Panel recommends that better integration and prioritization be effected by the existing TRADOC integrating centers and by HQ TRADOC, with management discipline applied by the Army Acquisition Executive through a HQDA focal point.

The Army has taken some steps to insert LTF considerations in the development process (e.g., inclusion of LTF in AR 70-1, Army Systems Acquisition Policies and Procedures, as indicated in Appendix B), but to be effective, LTF criteria should be raised to the status of "firm requirements" throughout the overall RD&A process.

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ISSUE 3: SOLDIERS ARE REQUIRED TO CARRY HEAVY AND BULKY ELECTRONIC GEAR

FINDINGS:

- EVERY SITE VISIT DISCLOSED PROBLEMS AND COMPLAINTS WITH THE SOLDIER'S PORTABLE ELECTRONIC EQUIPMENT (HEAVY, TECHNOLOGY 10-30 YEARS OLD)
- BUT, ELECTRONIC TECHNOLOGY HAS IMPROVED CONTINUOUSLY IN POWER CONSUMPTION, WEIGHT, VOLUME, AND MEAN TIME BETWEEN FAILURE
- NEWER PIECES OF ARMY ELECTRONIC EQUIPMENT (E.G., LASER RANGEFINDER) HAVE LITTLE COMPONENT INTERCHANGEABILITY, (E.G., INCOMPATIBLE BATTERIES)
- THE ARMY IN THE FIELD WANTS TO TAKE ADVANTAGE OF CURRENT ELECTRONIC TECHNOLOGIES

ISSUE 3: SOLDIERS ARE REQUIRED TO CARRY HEAVY AND BULKY ELECTRONIC GEAR

RECOMMENDATIONS:

- THE ARMY IMPLEMENT A PROGRAM TO:
  1. IDENTIFY NOW ALL SOLDIER PORTABLE ELECTRONIC EQUIPMENT THAT CAN BE SIGNIFICANTLY LIGHTENED BY TODAY'S TECHNOLOGY INSERTION
  2. DEVISE AN IMMEDIATE AND PERIODIC REPLACEMENT PROCEDURE FOR ALL SUCH IDENTIFIED ELECTRONIC EQUIPMENT
     - ALL SPECIFICATIONS SHOULD BE OF THE PERFORMANCE, NOT DESIGN TYPE
     - BUT, COMMONALITY OF CERTAIN NON-UNIQUE COMPONENTS (E.G., BATTERIES) BE MANDATED WITH REGARD TO FORM AND FUNCTION

Discussion (Issue 3):

Much progress has been made in lightening the soldiers load, but infantrymen continue to be burdened with the weight and bulk of a variety of heavy communications and other electronic and electro-optic equipments. As the soldier's effectiveness continues to increase, the quantity and diversity of these equipments increase, thus placing an increasing load on a soldier who is, in many cases, already severely loaded.

In the light divisions, the man-portable electronics gear causes one of the heaviest and most cumbersome back-packs - thus significantly limiting battlefield mobility and agility. The design and construction practices of the gear do not reflect the most modern electronic technologies, but are 10 to 30 years old. In particular, quantities and diversity of the batteries required to power them are excessive and unreasonable; spare batteries are one of the major training expenses for the Division. For a 15 day exercise the 7th ID Ready Brigade requires 44,640 batteries of the 6 most commonly used types, weighing 34,000 lbs and costing more than $200,000. Each of the equipment types appears to be independently designed and procured without consideration for commonality or interchangeability of parts with other equipment types and without consideration for the duty cycles of operation of the equipment (and the potential benefits of common rechargeable batteries).

Rapid changes have occurred in the field of electronics over the past few decades. Each succeeding decade has brought forth a new level of design, allowing increased performance with reduced space and power, a different manufacturing technology base, and improved reliability, yet the electronic gear carried by the men of the light division represents the design and manufacturing technology of the late 50's and early 60's.

Technologically obsolete equipment need not and should not be deployed into Army units where the generations of models can change faster than the length of the current Army acquisition process. In the case of radios, the penalty the Army is now paying is a loss of agility on the battlefield because heavy soldier-carried radios are being used when currently available commercial technology could reduce the weight by more than a factor of two.

At each site visited the Panel heard expressions of frustration concerning both the current electronic gear and that being promised. It is commonly believed (and expressed) that the difficulty lies in the complexity and duration of the acquisition cycle. Troops have even purchased (and demonstrated to the Panel) low-cost "walkie-talkies" for field exercises.

Discussion (Issue 3) cont'd

This Panel is well aware that this is not a new finding, nor is it the first time an ASB Panel has commented on it. But electronic technology is moving so rapidly, and the level of troop frustration is so high that special attention is merited to the development of a strategy and/or structure to achieve the insertion of currently available electronic technology into the force quickly and in quantity. In areas where technology improvements are being achieved every year or so, means to achieve common operability and replacement interfaces for different models being introduced into the Army must be devised.

The recommendation of the Panel is straightforward - identify the man-carried electronic gear that obviously can be lightened, specify the interfaces with other equipments so new technology can be inserted without the requirement for complete equipment conversion, but mandate commonality (or, at the minimum, interchangeability) in certain components such as batteries which perform a common function (but frequently are "tailored" by the developer to appear unique).

The Panel believes it important for Army management to reconsider whether the same policies and procedures can continue to be applied to the acquisition of such disparate items, for example, as missile systems, radios, and batteries. Different approaches appear appropriate for different types of items. Where no new technology is needed, the Army has provided for non-developmental item (NDI) procurement. However, in the case of radios and batteries, it is not evident that even this innovative procedure will provide a means for the Army rapidly to deploy in quantity to its forces items incorporating ever-changing technology. It is appropriate to consider even newer techniques (for example, leasing with contractor updating was one approach suggested to the Panel).

Army Management needs to create and implement a strategy for electronic technology insertions which is not limited by the existing "concept driven requirements system" and the lengthy development and acquisition process. This is particularly important where fielded Army equipment is generations behind the commercial equipment. It is essential that the Army use innovation, which is a principal U. S. attribute and strength, to achieve managemement and procurement policy breakthroughs.

ISSUE 4: THE ARMY'S EFFORTS TO REDUCE FUEL CONSUMPTION OF COMBAT AND COMBAT SERVICE SUPPORT VEHICLES HAVE NOT BEEN EFFECTIVE

FINDINGS:

- REDUCTION OF FUEL CONSUMPTION EXCEEDS ALL OTHER OPTIONS TO LIGHTEN THE ARMY'S FLEET OF VEHICLES, BUT HAS NOT BEEN A MAJOR CONSIDERATION IN THE DEVELOPMENT OF ARMY VEHICLE SYSTEMS
- FUEL CONSUMPTION HAS GONE UP DRAMATICALLY IN VEHICLE SYSTEMS (M1 70% > M60, HMMVV 30% > JEEP, M2/3 70% > M-113, APACHE 60% > COBRA)
- ADVANCED VEHICLE PROPULSION TECHNOLOGY AND ASSOCIATED WEIGHT REDUCTION CAN REDUCE OVERALL VEHICLE FUEL CONSUMPTION BY UP TO 50%
- FUEL CONSUMPTION IS NOT STATED AS AN ARMY BATTLEFIELD DEFICIENCY AND THEREFORE DOES NOT RECEIVE PRIORITY

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ISSUE 4: THE ARMY'S EFFORTS TO REDUCE FUEL CONSUMPTION OF COMBAT AND COMBAT SERVICE SUPPORT VEHICLES HAVE NOT BEEN EFFECTIVE

RECOMMENDATION:

- THE ARMY ESTABLISH A MAJOR STRATEGIC GOAL TO REDUCE THE OVERALL FUEL REQUIREMENTS FOR ITS COMBAT AND COMBAT SERVICE SUPPORT VEHICLES BY 50 PERCENT
  - ESTABLISH FUEL EFFICIENCY AND CONSUMPTION STANDARDS FOR ALL NEW VEHICLE ACQUISITIONS (E.G., AFV)
  - ENHANCE SUPPORT FOR R&D TO INCREASE FUEL EFFICIENCY AND COUPLE THIS R&D INTO ALL VEHICLE PROCUREMENTS
  - MODIFY THE BATTLEFIELD DEFICIENCY IDENTIFICATION PROCESS TO MANDATE EFFORTS TOWARD REDUCED FUEL CONSUMPTION

Discussion (Issue 4):

During a wartime scenario a mechanized division consumes 3,000 tons of supplies per day. Stated another way, every 27 days a mechanized division consumes its own deployment weight in supplies, 50 per cent is for POL; the same percentage holds for a light division. These facts have driven the Panel to concentrate on the fuel consumption issue as one of the key issues in LTF. Reducing fuel consumption also has a direct benefit in reducing the costs, both peacetime and wartime, of purchasing, handling and distribution.

Fuel consumption has gone up dramatically in several of the vehicle systems recently procured by the Army. The net effect is a significant increase in the total fuel consumption for the Army's fleet of vehicles. In fact, for the armored and mechanized divisions, the number of fuel tankers assigned to a division increased dramatically from 35 to 65, to handle the greater fuel consumption requirements for the recently fielded systems.

The ASB 1984 Summer Study, Technology to Improve Logistics and Weapons Support for Army 21, noted the alarming trend toward higher fuel requirements and recommended increased Army action to control the growth. Army's efforts to date have not been effective, and the need appears even greater today in view of the development of the AirLand Battle philosophy and deep strike capabilities with ever-lengthening and highly vulnerable logistics lines.

Information received by the Panel on past and current vehicle program procurement has shown that little attention has been given to vehicle fuel consumption. Fuel efficiency has been a sometime performance specification (e.g., the LHX engine and the procurement of the M939-A2, 5 ton truck) but these are not aggressive specifications to achieve the fuel consumption goals which the Panel believes are possible. Fuel consumption standards should be mandated for all vehicle acquisition programs.

The Panel believes that a 50 percent reduction in fuel consumption by the combat and CSS vehicles is achievable through a combination of new propulsion system technology, weight reduction, and the resultant decreased number of vehicles in the support chain. There are many potential opportunities for reducing fuel consumption ranging from heavy combat vehicles (e.g., M1 tank), other ground vehicles (e.g., truck), aircraft and the numerous auxiliary power units which provide electricity for the Army. But this can be accomplished only if forced by the highest levels of Army Management. As described in Appendix D, the same tactic was required and was successful in the 1970's during the fuel emergency in the U. S. when Congress passed a public law mandating the level of automobile consumption. The automotive technologists and developers responded only when firm requirements were established and enforced.

Discussion (Issue 4) cont'd

The Panel also notes that fuel consumption is not listed as an Army battlefield deficiency. Since this deficiency list forms the principal basis used by TRADOC and AMC to align funding priorities for programs in the Army Long Range Research and Development Plan (LRRDAP), fuel efficiency efforts are not being adequately resourced and (probably) could never be accomplished within the present framework of the requirements development process.

In summary, the Army's effort to significantly reduce fuel consumption appears weak and fragmented. There is no consistent requirement that challenging fuel consumption requirements be a major consideration in developmental efforts. There is little relevant R&D underway in the Army to address this issue and there is no single point of focus for the limited effort. There is no urgency or priority for the insertion of proven fuel consumption fixes into the current vehicle fleet or for new procurements. Considering the potential to significantly Lighten the Force -- and particularly in view of lengthened logistics requirements in an AirLand Battle scenario -- fuel consumption reduction demands more priority and management attention.

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ISSUE 5: THE ARMY IS NOT ADEQUATELY SUPPORTING THE DEVELOPMENT AND EXPLOITATION OF TARGET DISCRIMINATION TECHNOLOGY (TDT) WHICH HAS THE POTENTIAL FOR NEW SMART WEAPONS THAT CAN SIGNIFICANTLY LIGHTEN THE FORCE

FINDINGS:

- ADVANCES IN TDT CAN BE USED BOTH TO IMPROVE EXISTING AND FUTURE PRECISION-GUIDED MUNITIONS (PGM) AND TO DEVELOP A NEW CLASS OF SMART WEAPONS
- THE ARMY'S TDT PROGRAMS ARE DISPERSED AND LACK OVERALL PLANNING AND MANAGEMENT
- TDT WEAPON SYSTEMS HAVE THE POTENTIAL FOR REDUCING THE ARMY'S LOGISTIC TAIL WHILE INCREASING EFFECTIVENESS
- THERE IS A NEED TO ANALYZE THE REQUIRED CHANGES IN DOCTRINE AND OPERATIONS TO REALIZE TDT POTENTIAL

ISSUE 5: THE ARMY IS NOT ADEQUATELY SUPPORTING THE DEVELOPMENT AND EXPLOITATION OF TARGET DISCRIMINATION TECHNOLOGY (TDT) WHICH HAS THE POTENTIAL FOR NEW SMART WEAPONS THAT CAN SIGNIFICANTLY LIGHTEN THE FORCE

RECOMMENDATION:

- A MANAGER SHOULD BE DESIGNATED FOR THE TDT PROGRAM, INCLUDING:
  - FORMULATION OF POTENTIAL WEAPON SYSTEMS CONCEPTS WITH APPROPRIATE TECHNOLOGY DEVELOPMENT AND EXPLOITATION
  - ANALYSIS OF THE IMPACT OF INTRODUCING A PROPER MIX OF THESE SYSTEMS ON DOCTRINE, STRUCTURE, AND OPERATIONS
  - ASSURANCE OF A CRITICAL MASS TECHNOLOGICAL EFFORT

Discussion (Issue 5):

TDT permits automatic discrimination between targets and background and, in more advanced versions, discrimination among target types. When placed in a region known to contain targets, TDT enables a weapon to automatically guide itself to a target and, in more advanced forms, to automatically select and lock-on to a target of a specified type.

During the past five to ten years there have been rapid advances in TDT applicable to existing and new classes of PGMs. Advances have occurred in computer power, multi-spectral systems, 3-dimensional laser sensors, 2-and 3-dimensional shape recognition and special purpose computer architectures. These advances make possible improvements in existing PGM's and the creation of new improved PGM's which have single shot probabilities of kill (Pk's) approaching one. Thus, when properly employed these weapons have the potential to greatly reduce the number of rounds per kill and, as a consequence, can result in a significant reduction in the ammunition tonnage per day required to sustain the force. Inasmuch as ammunition constitutes 40 per cent of logistical resupply, "smart" weapons incorporating TDT have a real potential to lighten the force with the application of appropriate doctrine and tactics.

Smart weapons can be used in both the direct and indirect fire mode, but it is likely that the major contribution would be in producing an indirect fire capability against selectable classes of targets, 2nd echelon or follow-on forces, thereby increasing the survivability of the Forces at the Forward Line of Our Troops (FLOT) and contributing to the disruption of an enemy offensive action early in the battle.

There are a number of smart weapons programs in varying stages of maturity currently under way in the Army. These include Multiple Launch Rocket System (MLRS), Joint Service Target Attack Radar System (JTACMS), Search and Destroy Armor Munition (SADARM) and Hellfire. But there is no single focus in the Army for the development and weapon systems application of TDT. The relevent work is being performed in at least eight major organizations. Furthermore, there is little or no unified planning and management of these widely dispersed activities, and since the work is often funded and performed as parts of specific weapon system development programs, duplication and technology transfer difficulties can arise. The Panel noted (see Appendix E) that 37 TDT-related programs are being conducted by eight Army agencies, at a total funding level of $32 million.

Target discrimination technology is continuing to advance not only within the Army but in the Air Force, DARPA, NASA and the commercial machine vision community. In view of the dispersed Army effort and recognizing the distinct difference between utilization of so-called "dumb" and "smart" weapons, overall systems management is required to correlate R&D, development, and evolving weapons concepts with the required changes in doctrine, structure, and operations.

The necessary overall systems management within the Army is not apparent to the Panel; assignment of a single manager is recommended at DA Staff level.

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ISSUE 6: THE ARMY NEEDS TO IDENTIFY AND EXPLOIT LONG-TERM TECHNOLOGY TRENDS SPECIFIC TO LTF

FINDINGS:

- SELECTED PACING TECHNOLOGIES, WHEN BROUGHT TO MATURITY CONCURRENTLY, WILL PROVIDE A LIGHTENED AND IMPROVED FORCE
  - LOW HEAT REJECTION ENGINES (E.G., CERAMIC) TO HALVE FUEL USE AND WEIGHT
  - COMPOSITES AND CERAMICS FOR 20% LIGHTER ARMOR AND STRUCTURE
  - ACTIVE ARMOR AGAINST KINETIC ENERGY AND CHEMICAL ENERGY THREATS
  - ELECTRICALLY-POWERED WEAPONS (HPM, LASER, CP, EM, or ET) FOR REDUCED WEIGHT AND/OR INCREASED MUZZLE VELOCITY AND ENERGY, WITH ELECTRICAL VEHICLE PROPULSION COMPONENTS (I.E., GENERATORS, MOTORS)
  - POWER CONDITIONING EQUIPMENT TO ACCOMMODATE BOTH VEHICLE PROPULSION AND THE ELECTRICAL WEAPON
  - AND, WHEN AVAILABLE, SUPERCONDUCTIVITY TO MAKE EVEN LIGHTER MORE EFFICIENT ELECTRICAL DEVICES

ISSUE 6: THE ARMY NEEDS TO IDENTIFY AND EXPLOIT LONG-TERM TECHNOLOGY TRENDS SPECIFIC TO LTF

FINDINGS (CONT'D):

- PROGRAM DRIVEN TECHNOLOGIES MATURE MORE RAPIDLY THAN TECHNOLOGIES IN A DISPERSED TECH BASE
  - A PROGRAM DRIVER FOR THE ABOVE TECHNOLOGIES IS AN ALL-ELECTRIC WEAPON SYSTEM IN THE FORM OF AN ELECTRICALLY-DRIVEN ARMORED VEHICLE CONFIGURED EITHER AS A MOBILE AIR-DEFENSE GUN SYSTEM, A DIRECT FIRE ANTI-ARMOR WEAPON, OR AN INDIRECT FIRE MOBILE ARTILLERY SYSTEM

RECOMMENDATIONS:

- ADOPT A LONG-RANGE TECHNOLOGY FORECAST PROCESS
- INITIATE THE CONCEPT DEVELOPMENT OF AN ALL-ELECTRIC WEAPON SYSTEM UTILIZING THE DEFINED PACING TECHNOLOGIES WITH A SELF-STANDING ADEA-LIKE MANAGEMENT

Discussion (Issue 6):

Prior to defining the significant issues, findings and recommendations in this Summer Study, the Panel had the opportunity to examine a number of technologies and systems during the course of 15 site visits. Researchers, developers, operators, planners, and commanders were forthright in articulating their perceptions of the needs, opportunities and technologies. A surprisingly strong interest was expressed in providing a "vision of the future" for the Army. As reflected by one commander during the Panel's visit to an active division ... "We're always catching up, we don't want just more of the same, let's get ahead, where should we be 20 years from now?" In a sense that question is a paraphrase of the Terms of Reference as applied to LTF -- What are the pacing technologies? - What system should be emphasized? - How can those technologies be integrated?"

As described in Appendix F, the Panel evolved a listing of key technology drivers and opportunities to lighten the force, based on the various inputs, including an examination of:

- Technologies supported in the AMC/LABCOM and DARPA tech base, as well as the Panel's knowledge of other Government and industrial research.
- Army's technology demonstration program.
- Notional future weapons systems compiled by AMC/LABCOM.
- Army's concept formulation process.

Evident in the listing is the strong technology trend toward increased usage of computational/electronic/electrical power. This is demonstrated also in other national programs ranging from the space defense initiative to experimental solar-powered automobiles to laboratory superconductive devices. One attribute of this technology trend is a continual reduction in size and weight -- a continual movement toward "lightness."

The Panel recognizes that the technologies required for a weapon system mature more rapidly when identified with a self-standing separately-managed system development program, rather than as part of a dispersed technology base program. Therefore, as a focus for the future, and utilizing the R&D investments and the progress already being demonstrated in Army, DOD, NASA and industrial programs, the Panel recommends that Army Management initiate an all-electric weapon system program combining a number of pacing technologies as shown in the above briefing charts and described in more detail in Appendix F.

Discussion (Issue 6) cont'd

The electrical weapon system envisioned consists of a light armored vehicle powered by electric motors. It is equipped with a high velocity, high kinetic energy long range electric weapon. Heavy kinetic and chemical energy threat protection is achieved through the use of active armor. For small caliber protection the armor is a combination of advanced composites and ceramics augmented with appropriate passive and reactive components. The prime power for both vehicle and weapon propulsion is a motor-generator set powered by an efficient, high-temperature, low-heat-rejection ceramic engine using JP-8 fuel. The electrical system makes use of room temperature superconductors throughout to maximize efficiency and reduce weight.

The operational role of such a system is envisioned as being in the direct fire mode used either as an (1) anti-aircraft weapon possibly including the Anti Tactical Missile (ATM) role, a (2) lighter weight anti-armor vehicle or, in the indirect fire mode, as a (3) general light artillery weapon.

Such a system is realizable in the future by bringing technologies currently in the technology base to maturity. The time frame projected is long term, 20-30 years, for full technology maturation and system development, but the technologies as they mature have application to the upgrading of current equipment and to new system developments. In particular, those technologies associated with electrical power (low-heat-rejection engines, power generation, power conditioning, and superconductivity) will provide a near-term high payoff to the field Army for on-site electrical power generation, both fixed and portable.

The definition of specific pacing technologies requires a statement of the proposed application -- in the case of this study the objective is to lighten the force -- and an understanding of available technologies and their status. It would have been helpful to the Panel if the Army had in place a procedure for technological forecasting with an assessment of status, somewhat akin to the Air Force's Forecast II but tailored to the Army's needs. The Panel considers that an Army Technology Forecast is necessary to the health and progress of the technology base program, and has encouraged Army Management to undertake such a Forecast.

SUMMARY OF RECOMMENDATIONS

- AGREE ON, AND ADOPT, A DEFINITION FOR LTF
- ENFORCE LTF DISCIPLINE
- REPLACE, PERIODICALLY AND REGULARLY, OUTMODED PORTABLE ELECTRONIC GEAR
- DEVELOP AND EXPLOIT THE TECHNOLOGIES AND TACTICS FOR SMART AND BRILLIANT WEAPON SYSTEMS
- EFFECT A REDUCTION IN COMBAT AND COMBAT SERVICE SUPPORT VEHICLE FUEL CONSUMPTION BY 50%
- ACCOMMODATE TECHNOLOGY INSERTION COINCIDENT WITH THE BATTLEFIELD DEFICIENCY PROCESS
- ADOPT A LONG RANGE TECHNOLOGY FORECAST PROCESS
- INITIATE AN ALL-ELECTRIC WEAPON SYSTEM CONCEPT DEVELOPMENT, AND SUPPORT ITS PACING TECHNOLOGIES

APPENDICES

APPENDIX A

THE OBJECTIVE IN LTF AND A DEFINITION

Introduction

"LTF" has different meanings to different elements of the Army, ranging from equipment weight reduction, to the soldier's load, to packaging, to organizational changes. Table A-1 illustrates the variety of responses when the Panel met with representatives of the TRADOC Schools.

In the context of the Army's objectives to deploy a force rapidly outside the U. S., mass and particularly the mass of the initially deployed force (without its sustaining support) is not a sufficient measure of "LTF". Defining the light ID as one that can be moved with (for example) 500 C-141 equivalent sorties is better than measuring weight only because much of the deployment capability is constrained by cube or floor space area in the deploying aircraft. However, defining a light force by the number of sorties required to deliver just the initial deployment is also incomplete because the initially deployed force cannot sustain itself for a significant period of time. LTF proposals must be evaluated in terms of total force effectiveness which is dependent on the scenario.

Because of the different interpretations placed on "LTF" by those Army personnel sharing their views with the Panel, and because the Army is using the concept to make decisions on resources and forces without a clear articulation of what is to be achieved, the following systems-approach definition was developed by the Panel and utilized in its further deliberations.

> "LIGHTENING THE FORCE": Achieving a reduction in weight, cube, or square to improve: (1) force transportability to the battlefield (including both initial force deployment and sustainment) and/or (2) force agility on the battlefield, with a requirement to maintain or improve overall force effectiveness.

In the above definition, the following further definitions are useful:

Force:	An aggregation of military personnel, weapon systems, vehicles and necessary support, or combination thereof. A major subdivision of a fleet. (Reference: JCS Pub. 1, Dictionary of Military and Associated Terms)
Initial Force:	The first echelon of a force that enters an objective area with the capability to maintain itself for a period not to exceed 72 hours.
Agility:	The ability of friendly forces to act faster than the enemy. (Reference: FM 100-5)

TABLE A-1. TRADOC OBJECTIVES AND INITIATIVES LIGHTENING THE FORCE *

SCHOOL	OBJECTIVE	CURRENT INITIATIVES: MATERIEL	CURRENT INITIATIVES: DOCTRINE/ORGANIZATION
AIR DEFENSE ARTILLERY	IMPROVED TACTICAL AND STRATEGIC MOBILITY OF HIMAD SYSTEMS		
AVIATION	STRATEGIC DEPLOYABILITY SUSTAINMENT	- INTEGRATED COMMUNICATIONS AND NAVIGATION - AMMUNITION PACKAGING - COMPOSITE AIRFRAME STRUCTURES	- SELF-DEPLOYMENT - PLANNING
CHEMICAL	EFFECTIVE DECONTAMINATION WITHOUT LARGE QUANTITIES OF WATER, DECONTAMINANTS, AND BULKY EQUIPMENT	- LIGHTER DECONTAMINATION - NON-AQUEOUS DECONTAMINATION - MORE FUEL-EFFICIENT SMOKE GENERATORS - LIGHTER PROTECTIVE EQUIPMENT - SMALL DETECTION EQUIPMENT	- CONTAMINATION AVOIDANCE
ENGINEER	DEPLOYABILITY AND SUSTAINABILITY	- SMALLER, LIGHTWEIGHT, SCATTERABLE MINES - DIGITAL TOPOGRAPHIC SUPPORT SYSTEM - PACKAGED EXPLOSIVES - PREFAB STRUCTURES - SMALL EMPLACEMENT EXCAVATOR - QUICK RESPONSE MULTICOLOR PRINTER - PREPACKAGED BARRIER MATERIALS	- DOWNSIZE ENGR BATTALIONS
FIELD ARTILLERY		- LIGHTWEIGHT 155MM HOWITZER - SMALLER FIREFINDER RADAR WITH REDUCED CREW SIZE - LIGHT MET DATA SYSTEMS - ADVANCED FIELD ARTILLERY TACTICAL DATA SYSTEM	
INFANTRY	REDUCTION OF THE SOLDIER'S LOAD	- REDUCED WEIGHT OF INDIVIDUAL CLOTHING AND EQUIPMENT	
INTELLIGENCE	DEPLOYABILITY AND SUSTAINABILITY	- COMMON SENSORS, JAMMERS, AND GROUND STATIONS - UNMANNED AERIAL VEHICLES	
MILITARY POLICE	REDUCTION OF EQUIPMENT WEIGHT (TENTAGE, CAMOUFLAGE SYSTEMS, AND AMMUNITION PACKAGING)		
ORDNANCE		- LIGHTER MATERIALS HANDLING EQUIPMENT	- MANAGEMENT INFORMATION SYSTEMS
QUARTERMASTER	ENHANCED DISTRIBUTION SYSTEM AND REDUCTION IN SUPPLY CONSUMPTION	- FLEXIBLE CONTAINERS - MODULAR RATIONS	- CONSOLIDATION OF CSS SUBSYSTEMS - PRECONFIGURED UNIT LOADS - ENHANCED INVENTORY MANAGEMENT
SIGNAL		- LIGHTWEIGHT COMUNICATIONS SHELTERS - FIBER OPTIC CABLES - LIGHTWEIGHT DIESEL GENERATORS - DOWNSIZING OF SIGNAL EQUIPMENT	
TRANSPORTATION	TACTICAL AND STRATEGIC TRANSPORTABILITY	- FAMILY OF MEDIUM TACTICAL VEHICLES - PALLETIZED LOADING SYSTEM (PLS) - SELF-DEPLOYABLE WATERCRAFT	

* AS DESCRIBED TO THE PANEL BY TRADOC SCHOOLS

Based on the above definition of LTF and the information available to this ASB panel, it is not apparent that the total Army force has yet been lightened, specifically if one looks at a corps size force which includes the support that must be provided to the cutting edge. This lack of total force lightening is evident in an Army scenario involving projected deployment weights of two different five-division task forces. The original five-division task force (which included the 5th Mechanized Division) in the Joint Program Assessment Memorandum/Program Objective Memorandum (JPAM/POM) FY84-88 contained 720,000 tons of unit equipment. In a variation in JPAM/POM FY88-92 where the 5th Mechanized Division was replaced by one light division plus one heavy brigade, the weight of the unit equipment in the task force was 710,000 tons, only a one and one-half percentage change. In addition, combat performance for the "lighter" force as estimated by each of five different measures of performance (friendly casualties, friendly equipment losses, enemy casualties, enemy equipment losses, and terrain gain or loss) was judged not as good as those for the original forces.

In the context of the JCS Pub. 1 definition of a division (a major administrative and tactical unit/formation which combines in itself the necessary arms and services required for sustained combat, larger than a regiment/-brigade and smaller than a corps) it is not readily apparent that a light ID meets the definition. A light ID cannot engage in sustained combat without being reinforced. Therefore, in creating a light ID and shifting its support elements to corps, no apparent lightening of the force (i.e., total force) has occurred.

Transportability, the First Criterion

When sustainability as well as the deployability of the initial combat force is considered in the concept of "LTF," it is enlightening to review what and how much is consumed by different types of Army divisions. As illustrated below for a heavy and a light division, two points become evident. First, sustainment needs are large compared to the deployment requirements for the initial force. Secondly, the majority of the sustainment for both heavy and light divisions lies in two classes of supply -- POL and ammunition.

- Heavy Divisions. For heavy (mechanized and armor) divisions, the deployment weight, excluding combat support and CSS units in the corps slice, is 70,000 to 80,000 tons. Of this, approximately 38,000 tons or 50 percent is in the 10 tank and mechanized infantry battalions in each division. Of the 38,000 tons, about 18,000 tons are in the 300 tanks, each of which weighs some 60 tons. 8,500 tons in the division are in three 155mm artillery self-propelled (SP) battalions.

In sustained combat a heavy division is projected to consume 3,050 tons per day of supplies. The approximate breakout, based on data provided by the 4th Mechanized Division, is as follows:

Table A-2

Heavy Division Consumption

Type of Supplies	Daily Consumption Weight (Short Tons)
Class III: POL at 370,000 gallons per day	1,500
Class V: Ammunition for Sustained Combat	1,300
All other Classes	250
TOTAL	3,050

Thus, at 3,050 tons per day, each heavy division consumes its own weight each 27 days or less. Moreover, 50 percent of this consumption is in POL and 40 percent is in ammunition.

- o Light Divisions. A light ID, excluding combat support and CSS units in the corps, has a deployment weight of approximately 14,000 tons. 20 percent of this weight is in the one supply and maintenance battalion and another 20 percent is in the nine infantry battalions. Based on data received from the 7th ID, a light ID will consume its own weight in 19 days of combat.

The approximate breakdown of the daily consumption for the light ID is shown in Table A-3. As with a heavy division, over 90 percent of the consumption in a light division is for POL and ammunition. However, in the light division a greater percentage is for ammunition and a smaller percentage is for POL because there are fewer vehicles, and no armored vehicles, in the division.

Table A-3

Light ID Consumption

Type of Supplies	Daily Consumption Weight (Short Tons)
Class III: POL at 57,000 gallons per day	200
Class V: Ammunition for Sustained Combat	500
All other Classes	40
TOTAL	740

For both heavy and light forces, major targets of opportunity for improving deployability and sustainability lie in the areas of supply and consumption of both POL and ammunition. These are discussed further in Issues 4 and 5 of this report.

The Army must come to grips with the POL and ammunition issues as it considers deep attack missions with deployment of forces to remote locations where the resupply of hundreds of tons of POL and ammunition per day per division is difficult.

Agility, The Second Criterion

Force agility, the ability to act faster than the enemy, is considered to have both a physical and mental aspect when viewed from the commander's perspective.

The physical aspects of agility involve preparing for battle, moving to position prior to engagement, striking enemy forces, and transitioning to be ready to begin the cycle again, while minimizing vulnerability to enemy actions.

The mental aspects of agility include visualizing the objective, conceptualizing the battle, seeing and understanding the battlefield, making decisions, and directing the fight.

In terms of Army weapons and forces, there is a tendency to focus on the physical aspects of agility and particularly on the middle two -- namely, moving and striking. However, in terms of meeting overall objectives and with regard to LTF, there may be other equally important areas of opportunity. If one can help a force to transition to prepare for a second fight and/or if one can help a commander better to see and understand the battlefield, the overall impact on force agility and on total force effectiveness can be as great as improved speed or maneuverability of weapons systems. One important key is for Army commanders to be able to evaluate the relative importance of different aspects of agility to the potential outcome on the battlefield.

Definition

Lacking an Army-wide definition, the Panel has developed one for the purpose of this study, including the concepts of force transportability and force agility, as previously described in the Introduction to this Appendix. However, it is incumbent on the Army to reexamine the objectives and to enunciate a clearly articulated definition of "LTF" appropriate to today's Army.

APPENDIX B

SYSTEM INTEGRATION AND DESIGN DISCIPLINE

Introduction

The Panel, in reviewing the Army activities related to "LTF", has not been able to determine a sense of prioritization among the lightening efforts. Of equal or greater importance, focal points were not found in the DA Staff, TRADOC or AMC for analyzing and evaluating the potential total force contributions of alternative proposals for LTF. A consistent integrated systems approach or total force impact assessment process was not observed in the numerous organizations visited and briefings received. Most typically the system boundaries in the design and management process were envisioned as those in or near the combat force or functional element boundaries.

The Army Staff applied a systems approach to "Lightening the Soldier's Load." This is a refreshing approach which has provided excellent results and should be continued. In the larger context of "LTF," such dedicated staff efforts would benefit from more management guidance from senior Army leadership.

In the combined arms area, the Army has taken steps to obtain a combined arms MAA so it can better evaluate the tradeoffs and alternatives available across mission areas addressed by the individual schools and centers (e.g., infantry, armor, artillery, etc.). The results of such a combined arms MAA are not yet available (or at least were not available at the time of this ASB Summer Study) but this is another good example of the Army's efforts to take an overall systems approach by looking at the total force.

The combined arms MAA is not designed initially to include consideration of potential support variables to include, for example, variations in maintenance strategies or other alternative organizations or means for providing other elements of logistics support. Consideration of such support variables in evaluating future force structures and potential variations in doctrine needs to be included in Army analytic efforts.

One of the current and major tools for estimating the Army's support requirements for combat forces is the FASTALS (Field Army Simulation Theater Army Logistics Support) model. Therein the Army tries to account for effects such as (for example) the additional maintenance units needed to repair and maintain the added field transportation units which provide the added fuel for larger fuel-consuming combat vehicles. Many of the factors used to make such estimates are based on historical rules of thumb which may or may not be applicable to potential future design tradeoffs. The point is that the Army needs to address the ripple effects of design choices using a systems approach covering force transportability and force sustainability for any major LTF proposals and, in fact, for all major acquisitions.

As indicated in the discussion of Issue 1 and in Appendix A, POL and ammunition are the major sustainment items for both heavy and light Army divisions. Thus, for any new acquisition of vehicles or weapons, the potential impact on the total force of design tradeoffs involving POL and ammunition should be assessed. This is particularly true for a program such as the AFV because design choices there will affect many future combat and support systems. The full effects across the Army force structure (and not just the immediate combat units) need to be understood if Army decision makers are to make choices that will have major structural effects on the Army well into the 21st century. The Panel believes that the Army can and should use a quantitatively based systems approach to achieve better integration and prioritization of Army programs to meet overall goals and objectives.

The Panel believes that the specifiers and the developers of combat systems and other materiel need to exhibit better discipline in requirements statements and in the design process with regard to sustainability. Heretofore, design criteria seldom specified either limits or reductions in terms of fuel or parts supply requirements, or in the skills and personnel requirements to maintain and support the system as a whole.

Fortunately, there are in place the considerable resources indicated in Table A-4 for the analytical evaluation of tradeoffs, although the disciplined mechanism to meld those analyses is not yet apparent. Each parent organization at its HQ level needs to serve as the integrator of its individual interests with a single focal point for LTF efforts designated at HQDA level.

Table A-4

Major Army Analysis Agencies

Parent Organization	Analytic Organization	Force Level Focus	Manpower Strength
HQDA	Concepts Analysis Agency (CAA)	Theater	300
TRADOC	TRADOC Analysis Command (TRAC)	Tactical, Operational	600
AMC	Army Materiel Systems Analysis Agency (AMSAA)	Individual Item Performance	450

The same LTF discipline should be applied to the entire RDA process, not just transportability and sustainability. The Army has taken some steps to insert LTF considerations in the process. For example, it is included in AR 70-1 and AR 71-9, Materiel Objectives and Requirements, but is diffused as one of many items which "must be considered" (see Table A-5). To become a focused program, LTF design criteria need to be raised to the status of "firm requirements" throughout the overall RDA process.

Table A-5

LTF Requirement in AR 71-9

Army Regulation 71-9
Material Objectives and Requirements
Appendix D
Item D-5 Operational Characteristics

"The requirements and provisions for the following must be considered:

A. Compatibility with Existing Systems
B. Continuity of Operations (CONOPS) of a Base
C. Security
D. Transportation and Mobility
E. Reliability, Availability, and Maintainability
F. Standardization, including Commonality for Components, Software, Ammunition, Power, TMDE, etc.
G. International Standardization Agreements
H. Nuclear Survivability and NBC Contamination Survivability
I. Individual and Collective Protection Equipment
J. Adverse Weather and Reduced Visibility Conditions (Smoke and Obscurants), Operations and Military Operations in Urbanized Terrain, where applicable
K. Communications
L. Airdrop, Airlift Certification, and Jumppack
M. Lighten the Force
N. Camouflage
O. Climatic Design Types
P. Special Purpose Deception Materiel
Q. Directed Energy Survivability
R. P3I (include timeframe for block modifications)"

APPENDIX C

ELECTRONIC GEAR AND TECHNOLOGY INSERTION

Infantrymen carry a variety of communications and other electronic and electro-optic equipment. As the Army strives to increase the soldier's effectiveness, the quantity and diversity of these equipments tend to increase, thus placing an increasing load on an already heavily loaded soldier. In the opinion of the Panel, the situation has passed the point where additional capabilities can be added without reduction of the current load. Fortunately the technology exists to reduce the weight and bulk while improving the performance and reliability of electronic gear whether man-portable, vehicular, or for fixed installations.

The challenge for the Army is to incorporate current technology in its acquisitions and accommodate the insertion of new technology in fielded equipment.

In the light divisions, the portable electronics gear causes one of the heaviest and most cumbersome backpacks -- thereby significantly limiting battlefield mobility and agility. The designs and construction practices do not reflect the most modern electronic technologies, but are 10 to 30 years old. The gear is heavy and power consuming. Furthermore, the quantities and diversity of the batteries required appear to be excessive and unreasonable. Spare batteries are one of the major training expenses for the division and a major wartime logistics problem (for example, for a 15-day exercise, the 7th ID Ready Brigade, for the six most commonly-used of 22 battery types in its equipment, requires 44,640 batteries weighing 34,000 lbs and costing more than $200,000). Much of the gear has the appearance of being vehicle-mounted communications gear with modifications to allow it to be carried. Each of the equipment types appears to be independently designed and procured without consideration for commonality or interchangeability of parts with other equipment types and without consideration for the duty cycles of operation of the equipment (and the potential benefits of common rechargeable batteries). It is possible to markedly lighten the man-packed communications gear. Panel member estimates of possible weight reductions for different equipments vary between a factor of 2 and 5.

Three aspects of battery power supplies are of concern. First, many pieces of man-carried equipment require a different battery (22 battery types for 42 types of equipment in the 7th ID). It should be possible to use the same battery singley or in combination for most man-packed equipment. Second, since most of this equipment is used at relatively low duty cycle, it is possible to use rechargeable batteries to be recharged by a small lightweight sunpowered, hand- or foot-powered generator, or from the common power buss of idle equipment. Third, if a common power buss were incorporated, it would allow a piece of equipment to provide power to accessories (or other equipment in emergencies). Such capabilities can and should be incorporated in the design to permit a very significant reduction in battery stockage and resupply.

All members of the Panel are aware of the rapid changes that have occurred in the field of electronics over the past few decades. Each succeeding decade has brought forth a new level of design allowing increased performance with reduced space and power, a different manufacturing technology base, and improved reliability. Consider computers or compare the portable television sets of 1960, 1970 and 1980! Consequently, it is of great concern to note that much of the electronic gear carried by the soldiers represents the design and manufacturing technology of the late 50's and early 60's, with limited capability as compared to today's technology.

At each site visited the Panel heard expressions of frustration concerning both the current electronic gear and that promised. For example, the late 1950's technology communications equipment in the 7th ID (the AN/PRC 77 field radio weighs over 35 lbs, with accessories and batteries) is soon to be replaced by the late 1970's technology AN/PRC-119 SINCGARS manpack weighing over 20 lbs. Using today's technology, a further reduction to 10-15 lbs is feasible. It is commonly believed (and expressed) that one difficulty lies in the complexity and duration of the acquisition cycle.

As previously indicated in the Discussion of Issue 3, a real challenge and opportunity exists for the modification of current acquisition policies, both "conventional" and "NDI" to accommodate and enhance technology insertion. Electronic gear is a prime candidate.

But the problem with the inability to capitalize on technology is not limited to electronics. The Panel in the initial phases of the study was divided into three subgroups: operational, technology, and logistics. Each subgroup met with a cross section of Army representatives in each of these areas. A common thread found in these discussions was an overall frustration with the Army's inability to take advantage of current technologies to lighten the force. The operational group encountered the examples cited above for electronic gear. Army logisticians used commercial watch batteries and boots as examples of capable lightweight products not found in the Army. Army technologists in their "Lighten the Forces Study" for AMC Commanding General Thompson in 1985 indicated that exploiting NDI opportunities was the best method in the near term. Another significant example cited by operational forces was the availability of a multi-purpose light helicopter (MPLH) deployed with three of our allies, for rapid deployment for forced entry operations. ADEA, the Army's designated proponent for NDI equipment to lighten the force has not been highly successful in getting equipment fielded due in part to lack of the combat developer (TRADOC) and the materiel developer (AMC) being involved with ADEA in concept formulation and in the NDI and Quick Reaction Program (QRP) decision process.

These few examples are illustrative of the opportunities available with today's technology, and the need to create and implement a strategy for technology integration either within or outside the existing "concept driven requirements system." Electronics gear is an appropriate area within which to develop this strategy since both technology and engineering are well in hand today; an enhanced management and procurement policy is required.

APPENDIX D

THE NEED AND THE EFFORT TO REDUCE FUEL CONSUMPTION

An examination of the requirements to deploy a division immediately focuses attention on vehicles as a major target for "LTF." For example, it takes 510 C-141 equivalent aircraft to move a light ID. Of this number, 150 aircraft are required to move the trucks. For a mechanized division, a total of 1,820 C-141's and 360 C-5B's are needed to move the division. Of that number, 300 tanks must be moved by C-5B's, one per aircraft. These data clearly point to the vehicles as a major opportunit for LTF. Looking beyond the vehicles themselves, in a wartime scenario a mechanized division consumes nearly 3,000 tons of supplies per day. Stated another way, every 27 days a mechanized division consumes its own deployment weight in supplies, and of this amount, 50 percent is for POL. The situation is analogous in a light division. These facts have driven the Panel to focus on the fuel consumption issue.

Given that POL is a major component of the logistics burden, the direct payoff resulting from significantly reduced fuel requirements is apparent. Not so obvious are the following additional benefits:

- In-theater requirements for POL purchasing, handling and distribution will be cut in essentially the same proportion as the reduction in fuel consumption, a benefit in both peacetime and wartime.

- Refinery capacity and fleet tankage, both scarce resources in time of war, will be significantly relieved.

These factors become of even greater significance in the scenarios for light divisions and special forces where logistics resupply is difficult and in some cases totally by air.

Information received by the Panel on past and current vehicle program procurements has shown that little attention is given to vehicle fuel consumption. Fuel efficiency has been a performance specification (e.g., the LHX engine and the procurement of the M939-A2 5-ton truck), but these are not aggressive specifications to achieve the fuel consumption goals which are possible. Challenging fuel consumption standards must be established for all vehicle acquisition programs if the potential savings inherent in the Panel's recommendation are to be realized. Note that total fuel consumption for mission accomplishment is the key --not solely the fuel efficiency of individual components.

The Panel has noted that fuel consumption is not listed as an Army battlefield deficiency. Since this deficiency list forms the principal basis used by TRADOC and AMC to align funding priorities for programs in

the Army LRRDAP, fuel efficiency efforts are not being adequately resourced. For example, the low-heat-rejection engine development work done on the 5-ton truck appears to offer a significant improvement in fuel efficiency (i.e., from 6.5 to 9 mpg); however, funding for this effort has been significantly reduced and is essentially zero in FY87.

The Panel recommends a careful reexamination of the battlefield deficiency identification process to determine if it may, in fact, be inhibiting the insertion of new technologies into Army equipments (such as reduced consumption engines as only one example).

Fuel consumption has gone up dramatically in several of the vehicle systems recently procured by the Army. In each of the specific cases cited below, the new vehicle system has additional capabilities or supports additional missions, so the comparison is not strictly "apples to apples." For example, Apache carries the Hellfire anti-tank weapon, which is more capable than the Cobra's TOW system, and the HMMWV replaces several vehicles, from the 1/4 ton jeep to the 5/4 ton truck. But the net effect is a significant increase in the total fuel consumption for the Army's fleet of vehicles. In fact, for the armored and mechanized divisions, the number of fuel tankers assigned to a division increased from 35 to 65 to handle the greater fuel consumption requirements for the recently fielded systems.

As a first approximation, the fuel consumption for a vehicle is proportional to its weight. Hence, any weight reduction will result in less fuel consumption. In addition, engine and transmission technology will permit new vehicles to be more fuel efficient than those now in the inventory. In the commercial world, for example, the achievement of Congressionally-mandated standards for improving fuel efficiency has resulted from both a weight reduction and engine and aerodynamic improvements. For military vehicles, the opposite has occurred. The M1 is 14 percent heavier than the M60 and uses 70 percent more fuel in an average 24 hour period. The HMMWV is 20 percent heavier than the jeep and uses 37 percent more fuel.

To illustrate the commercial reductions, the following is a direct quote from the ASB 1984 Summer Study, "Technology to Improve Logistics and Weapons Support for Army 21":

> ..."Progress can be made by institutionalizing the specification and procurement process for POL-consuming equipment. For example, it has been demonstrated in the civilian community that POL consumption can be reduced. By establishing requirements (i.e., by Public Law) and reacting to the pressure of higher fuel costs, the national and the automobile/-truck industry have succeeded in forcing technology to effect a dramatic reduction in fuel consumption of new vehicle fleets: a 93% improvement (miles per gallon) in ten years for automobiles, and 25% in eight years for diesel trucks. The Army can do the same by elevating requirements and specifications for POL consumption to a priority equivalent to other military performance specifications ... ."

The AFV program now being planned will continue to exacerbate the fuel consumption problem. Vehicles with a heavy chassis would be used for a variety of functions now supported by lighter vehicles. According to the briefings the Panel received, the Operational and Organizational (O&O) Plan contains no fuel consumption requirements nor are there weight restrictions. The sustainment cost estimates showed that POL costs for the AFV could be as much as 60 per cent greater than the alternative of upgrading the current force.

The Panel was encouraged by Army participation in the development and use of the all-purpose fuel JP-8, to be used for everything from helicopters and trucks to cooking stoves. The logistics advantages to the Army are obvious, and the directive by the Vice Chief of Staff, Army, to implement its use in Europe illustrates the need for and benefits of high-level Army attention.

The Panel believes that a 50 percent reduction in fuel consumption by the combat and CSS vehicles is achievable through a combination of new propulsion system technology, weight reduction, and the resultant decreased number of vehicles in the support chain. There are many potential opportunities for reducing fuel consumption, ranging from heavy combat vehicles (e.g., M1 tank), other ground vehicles (e.g., truck), aircraft and the numerous auxiliary power units which provide electricity for the Army. Within the Army, the major research activities have focused on developing propulsion systems for heavy combat vehicles (e.g., the Advanced Integrated Propulsion System (AIPS) program).

By attacking the fuel efficiency issue through low-heat-rejection (adiabatic-like) technology, savings are made in two ways: one is the direct saving due to a more efficient engine, and the second is by reducing the size of the propulsion system. For example, the requirements for cooling are reduced and the engine has fewer parts. For combat vehicles, the smaller volume for such an engine means there is a smaller volume which must be protected by armor. For the M1 the propulsion system accounts for 40 percent of the volume protected by armor. It is estimated that this armored volume could be reduced by half (i.e., 20 percent of the vehicle) as a result of the propulsion system being developed in the AIPS program.

It is Army policy to buy commercial engines for CSS vehicles (10 ton and below) and to depend on private enterprise to perform the research leading to more fuel efficient engines. The Army is doing very little research aimed at producing a breakthrough in engine technology. However, private industry has limited incentive to pursue significantly improved engine performance, and there is not an aggressive R&D effort to produce a breakthrough in engine technology. Hence, the Army is waiting on private industry to develop the next generation engine, and private industry is not likely to produce such an engine in the near future in the absence of incentives. The Panel believes that the Army should support an aggressive R&D effort

to develop a next generation engine, using ceramic components. The Panel feels that issues of producibility (manufacturability) and durability are solvable. The payoff is significant and necessary for a lightened force; the Army cannot rely solely on private industry.

In summary, the Army's efforts to reduce fuel consumption significantly appear weak and fragmented.

- o There is no requirement that reduced fuel consumption be a major specification in developmental efforts.
- o There is no urgency or priority for the insertion of proven fuel consumption fixes into the current vehicle fleet.
- o There is little relevant R&D underway in the Army to address this issue, and there is no single point of focus for the limited effort. The Army's battlefield deficiency identification process, in fact, appears to inhibit the effort.
- o Army fuel consumption has risen dramatically and poses a serious wartime battlefield deficiency.

Considering the potential to significantly lighten the force, fuel consumption efforts demand more priority and management attention. The need is further heightened by the newer battlefield scenarios which emphasize deeper penetration and rapid movement, with more vulnerable logistics lines.

APPENDIX E

TARGET DISCRIMINATION TECHNOLOGY AND THE APPLICATION OF SMART WEAPONS TO LIGHTEN THE FORCE

Definition

TDT enables weapons to automatically guide themselves to targets and, in more advanced forms, to automatically select and lock on targets of specific types. TDT in its various levels of development is applicable to all classes of PGM's as well as to Reconnaissance, Surveillance and Target Acquisition (RSTA) operations. TDT is sometimes referred to as Automatic Target Recognition (ATR).

For purposes of the present report, the classes of PGM's are defined as follows:

- Guided Munitions: Operator is in the loop to select target and assist in guidance.
- Smart Munitions: Many-on-many munition with auto lock-on, minimal target selection capability.
- Brilliant Munitions: Autonomous operation to search, detect, identify, acquire and engage targets (next generation).

Background

This report takes as a point of departure the December 1984 ASB Ad Hoc Subgroup report, "Follow-on Report on Intelligent Robotics," and extends its results to LTF. A single major finding of the cited ASB subgroup report was that discrimination of technology is rapidly reaching a stage of development where it can impact a number of Army needs.

The present report also is based on and extends the results of the 1984 ASB Summer Study "Technology to Improve Logistics and Weapons Support for Army 21." The latter study concluded that "...intense use of smart ammunition will lead to increased effectiveness and greatly reduced tonnage/day if area fire missions are limited to those of high effectiveness." Data cited elsewhere in the present report places the ammunition requirement for a typical division at 40 percent of the daily sustainment required; ammunition constitutes a major logistical burden and is a prime target of opportunity to lighten the force.

Recent Advances in Discrimination Technology

There have been rapid advances in TDT applicable to existing and new classes of PGM's within the last five to ten years. Advances in computer power, multi-spectral systems, 3-dimensional laser sensors, 2- and 3-dimensional shape recognition and special purpose computer architectures have occurred. These advances make possible improvements in existing PGM's and the creation of new improved PGM's which have single shot Pk's approaching 1. Thus, when properly employed these weapons have the potential to greatly reduce the average number of rounds per kill and, as a consequence, can result in a significant reduction in the ammunition tonnage per day required to sustain the force.

Relevant target discrimination technology work also is being performed within the Air Force and by DARPA. Liaison with the DARPA work is being maintained by the Army, but the Panel recommends a much closer coupling with these efforts. In addition, work in the civilian scientific communities (e.g., the NASA remote sensing community and the commercial machine-vision community) has much to offer, and monitoring their valuable technological development will enhance Army programs.

Application of TDT

At the recommendation of the aforementioned 1984 ASB Logistics and Weapons Support Study, the Army has undertaken studies of the impact of existing PGM's on ammunition supply reduction. This ongoing work is reported to confirm that when properly employed, PGM's will significantly reduce ammunition resupply needs. It is expected that extension of these studies to include further improved PGM's (sometimes referred to as "brilliant" weapons) will show even greater impact.

Smart and brilliant weapons can be used in both the direct and indirect fire mode, but it is likely that the major contribution will be in producing an indirect fire capability against selectable classes of targets, 2nd echelon or follow-on forces, thereby increasing the survivability of the US Forces at the FLOT, and contributing to the disruption of an enemy offensive action early in the battle.

These improved and new PGM's when employed with surveillance and target acquisition systems to designate areas containing targets, can be used against tanks and other vehicles, tube and missile artillery, anti-aircraft weapons, communications and electronic warfare installations, bridges and other high value targets which have distinctive signatures. In essence, it is necessary to exploit the capability smart weapons provide in being able to accurately deliver munitions against high value targets.

Obviously, smart weapons are unique and expensive as compared to conventional projectiles. The introduction of various types (and maturities) of these systems (such as MLRS, JTACMS, SADARM, Hellfire, etc.), into the Army inventory has resulted in modifications to doctrine and tactics. And since the operational capability of next generation weapons would provide a still newer dimension in the employment of PGM's, it is necessary to revisit various scenarios of land combat and analyze the further changes required in doctrine, organization and tactics.

Recommendation

The Panel found no effective focus in the Army for the development of target discrimination technology and weapon systems, with the required doctrinal and tactical changes. As indicated in Table A-6, the relevant development is being performed in eight major organizations. There is little apparent unified planning and management of these widely-dispersed activities, and since the work is often funded and performed as parts of specific weapon system development programs, duplication and technology transfer difficulties can arise. Therefore, the Panel recommends the designation of a manager (General Officer level should be considered) for the target discrimination technology program at DA Staff level with duties to include: formulation of potential weapons systems concepts; development of the doctrine, organizational structure, and tactical operations required for the utilization of the mix of present and next generation systems; and the allocation of overall resources including technology development. The strong inter-relationship between these elements requires overall coordination and management.

Table A-6

Army 1987 Automatic Target Recognition (ATR) Programs *

Organization	Program Types					
	Generic	LHX	Tank/AFV	Defense	Missiles/SM	Misc.
ARDEC			1			
AVSCOM		1				
BRDEC						1
CECOM	10	1		1		
COE	1	1			2	2
LABCOM	7		1			
MICOM				2	5	
TACOM			1			
FUNDING (K$)	15426	3625	5660	800	4346	2262
Total	$32,119K					

* Source: Report on Army's Automatic Target Recognizer R&D Activities, Center for Night Vision and Electro-Optics (CNVEO), 10 April 1984 (revised) RD-NV-D-11

APPENDIX F

PACING TECHNOLOGIES AND A FUTURE ALL-ELECTRICAL WEAPON SYSTEM

Introduction

As indicated in the Discussion of Issue 6, an all-electric weapon system is proposed as a technology driver based on the component technologies identified as critical to LTF. The time frame projected is long term, 10-20 years, for technology maturation and system development, although intermediate spinoffs are foreseen.

The electrical weapon system consists of a light armored vehicle powered by electric motors, equipped with a high velocity, high kinetic energy long range electric weapon. Active armor provides heavy kinetic and chemical energy threat protection; for small caliber protection the armor is a combination of advanced composites and ceramics with passive and reactive components. The prime power for both vehicle and weapon propulsion is a motor-generator set powered by an efficient high-temperature, low-heat-rejection ceramic engine using JP-8 fuel. The electrical system makes use of room temperature superconductors throughout to maximize efficiency and reduce weight.

Such a system is realizable in the future by bringing technologies currently in the technology base to maturity. The pacing technologies are as follows:

- Low-Heat-Rejection Engines. Good progress in materials such as silicon nitride and zirconia indicates the long-term feasibility of a high temperature low-heat-rejection reciprocating engine or turbine. Ceramics are already being applied as components to the high temperature parts and bearings of advanced engines. Problems to be addressed are dimensional control, tribology, and manufacturing technology.

- Composites and Ceramics. These materials are currently available in prototype quantities. Current work by the Army indicates that a 20% reduction in weight is possible with equal protection as compared to conventional armor. The development of manufacturing technology and a manufacturing base will bring costs down.

- Active Armor. Exploration of this approach is part of the DARPA armor anti-armor program. The concept is an extrapolation of the Navy Phalanx weapon system to small cross-section and higher velocity targets. Active armor will reduce the need for protection by heavier conventional passive or reactive armor.

- Electrical Weaponry. Current exploratory work addresses both electro-magnetic (EM) and electro-thermal (ET) guns. DARPA projects a demonstration program of EM technology by 1992 with a potential evaluation also of ET technology. Additionally, the Army is considering the merits of electrically-powered directed energy weaponry utilizing coherent, focused energy such as lasers, high-powered microwaves, and particle beams. (Although not an electrical technology, it should be noted also that ARDEC projects a demonstration of liquid propellant (LP) technology in the 1990 time frame.) As an example, high muzzle velocities of 4500 meters/sec and high energies of 25 megajoules are projected goals for EM propulsion with JP-8 as the prime energy source in the power generation system. Because of the higher energy density of JP-8 as compared to conventional chemical propellants (10:1), a 2.5 to 1 reduction in propellant volume can be projected using efficiency numbers of 27% conventional, 6% EM estimated on the basis of current technologies.

- Electrical Propulsion and Power Conditioning System. Components for vehicle propulsion have been developed and demonstrated in both wheeled and tracked vehicles, but further development is required for both electrical vehicle and weapon propulsion, including homopolar generators and motors, variable speed AC motors and generators, solid state power electronics controls, pulsed alternators, energy storage devices, and switches. These components, when available, should be configured into a common demonstration propulsion and power conditioning system with standardization to apply as a goal to emerging potential electrical weapon systems such as EM, ET, laser, particle beam and High Power Microwave (HPM).

- Room temperature superconductors will be needed to increase the efficiency of the electrical power system and to provide a significant weight and volume reduction. While elevated temperature superconductivity is still in its infancy, current rapid progress raises expectations of operation at room temperature and higher. The exciton theory of Bardeen, if confirmed for this class of materials, does not preclude the existence of superconductivity even well above room temperature. Coincident with the above technology developments, the need exists for continued efforts in:

    - Fault tolerant self-repairing electronics. With the rapid progress of integration levels and increases in density of integrated circuits, the current concepts of self repairability will be realizable without unduly increasing the acquisition cost. This technology, by significantly improving operational availability through improved reliability, will reduce the logistic tail.

- o Sensor fusion and automatic target acquisition will lighten the commander's load and will be important adjuncts as decision aids to efficient operations. Further progress in information sciences will make this an operational reality.

Although highlighted in the context of a projected weapon system, the Panel believes that the above technologies are critical to the Army on a broad front. As such, attention should be focused on these technology developments in the Army, in other parts of DOD, and in the civil sector.

The pacing technologies described above are a distillation of the many technologies and systems listed further in this Appendix; but the technology listings should not be considered complete. Only systematic planning with periodic and regular forecasting can define a firm direction to major technology thrusts for the Army. The work of the Panel (and certainly the efforts of in-house Army technologists as well as supporting industrial researchers) would have been aided immeasurably by the availability of an Army Technology Forecast. The Panel recommends that such a technology forecast be initiated.

Technologies and Systems Reviewed

Tables A-7 through A-11 list the technologies and systems examined by the ASB Panel before the technology selection most germane to lightening of the force was achieved in Issue 6. Although by no means inclusive, the six technologies of Issue 6 (as listed above) are considered to be most critical to lightening the force.

- o Table A-7 lists the top technology demonstration programs the Army is currently conducting. An examination of these programs was conducted by the ASB Panel during several briefings.
- o Table A-8 is a listing of notional future weapon system applications of current technologies in the technology base as compiled by AMC/LABCOM.
- o Table A-9 depicts the concept formulation process into which the Army Technology Forecast (recommended in Issue 6 and discussed above) can be integrated in a more formalized manner.
- o Table A-10 is a listing of lightening technologies supported in the Army's technology base which have been examined by the ASB Panel.
- o Table A-11 is a listing of the key drivers to lighten the forces and is the distillation of the information the Panel reviewed in the data listed in the previous Tables. The items in Table A-11 served as the foundation for the issues, findings, and recommendations in this study.

With regard to some of the investigations into newer weaponry, conceptual drawings of an EM gun as compared to a conventional gun are shown in Figure 1. The coil shown in (c) can be substituted for the rail in (b) giving rail or coil guns as alternative means of implementation. Both are being pursued in advance development by DARPA/ARDEC.

The attributes of EM guns as compared to conventional and LP guns are shown in Table A-12 below.

Table A-7

Top 20 Technology Demonstrations

1. Advanced Mine/Countermine (AM/CM)
2. AirLand Battlefield Environment (ALBE)
3. AirLand Battlefield Management (ALBM)
4. Army/DARPA Distributed Communications Processing Experiment (ADDCOMPE)
5. Aided Target Recognition/Multi-Sensor Fusion (ATR/MSF)
6. Biotechnology (BIOTECH)
7. Combat Vehicle Armor/Anti-Armor (Composite Hull, KE/CE Warhead, and Hypervelocity Missile)
8. Crew-Vehicle Interface (CVI)
9. Elevated Target-Acquisition System (ETAS)
10. EML/LP/Unicharge Demonstrations
11. Expert Systems for Combat Vehicles Diagnostics Prognostics/Embedded Training
12. Integrated Air-to-Air Weapons (INTAAW)
13. Lightening the Soldiers Load (LSL)
14. Lightweight, Indirect-Fire Weapon Systems (155 mm)
15. NBC Detection, Protection, and Decontamination
16. Precision Deep Attack
17. Propulsion 21
18. Robotics Exploitation (ROVEX)
19. Unmanned Aerial Vehicle and Payloads Demo (UAV)
20. Very Intelligent Surveillance and Target Acquisition - Combat Information Processor (VISTA-CIP)

Table A-8

Next Generation and Notional Systems

Advanced Airdrop Systems-2000
Advanced Anti-Tank Weapons Systems-Heavy (AAWS-H)
Advanced Cargo Aircraft (ACA)
Advanced Combat Weapons System
Advanced Countermine System
Advanced Electro-Optical Countermeasures System
Advanced Field Artillery System
Advanced Infrared Countermeasures System
Advanced Integrated Combat Clothing
Advanced Laser-Warning and -Locating System
Advanced, Light-Weight Electronic Support Measures/Electronic Intelligence Tactical System
Advanced Retaliatory Chemical Munitions
Armored Family of Vehicles - Assault-Force Systems
Armored Family of Vehicles - Assault-Force and Battle-Support Force Systems
Armored Family of Vehicles - Robotic Combat Vehicles
Battlefield Spectrum-Management Systems
Combat Field Feeding System - Army 21
Combined Arms Multipurpose Missile (CAMM)
Command-Adjusted Trajectory System (CAT)
Commander's Decision Aids
Controllable / Smart Mines Systems
Counter-Surveillance and Tactical Deception
Distributed Communications Systems
Distributed Data-Processing System
Electric Power Sources
Electro-Magnetic, Direct-Fire Weapon System
Forward-Area Air Defense C2I Block II (Objective System)
Forward-Area Air Defense - Line-of-Sight Forward (Heavy) (LOSF-H) Block II
Forward-Area Air Defense - Line-of-Sight Forward (Light) (LOSF-L) Block II
Forward-Area Air Defense - Non-Line-of-Sight (NLOS) Long-Range Anti-Tank (LRAT)
Follow-on Smart Munitions - Anti-Tank Missile System (A-TACMS) Block III
Follow-on Munitions
Future Attack Rotorcraft
Future Family of Vehicles
Future Unmanned Aerial Vehicles (FUAV)
Improved Apache
Interceptor 2000
Jammer 2000
LHX - Light Helicopter Family
Lightweight Indirect-Fire Weapon System (155 mm How)
Lightweight Multi-Purpose Tactical Shelter
Medium-Range Surface-to-Air Missile (MSAM) System
Military Support and Assault Bridging
Multi-Spectral Obscurants
M1A1 Modifications (Block III)
M2/M3 Modifications (Block III) - Bradley Fighting Vehicle System
Nuclear, Biological, & Chemical Decontamination Systems
Nuclear, Biological, & Chemical Detection & Reconnaissance
Reconnaissance, Surveillance, & Target Acquisition System 2000
Tactical Logistics System
Tele-Operated Mobile Anti-Armor Platform (TMAP)

TABLE A-9

CONCEPT BASED REQUIREMENTS SYSTEM

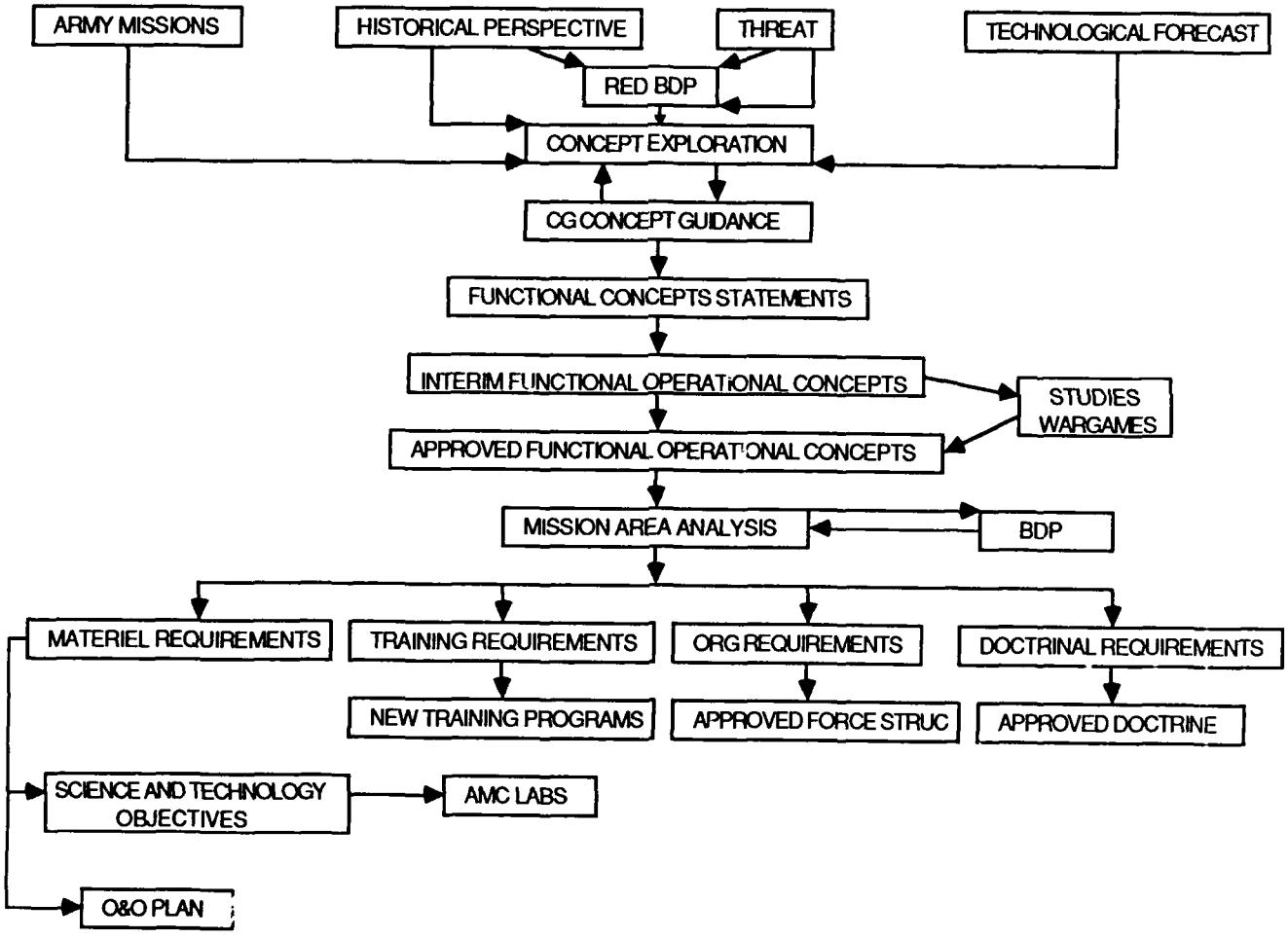

Table A-10

Army Technology Base Activities Briefed to the Summer Study

ASB - Lightening the Force, Tech Base/Opportunities

U.S. Army Laboratory/Command	Technology	Application
Laboratory Command	Need for an Evaluation Mechanism	"What if" Weight Analysis at Battalion Level
Armament R&D Center	Propellant Formulation and Round Fabrication	Cannon Caliber (25mm) Caseless System
Armament Munitions Chemical Command	Contamination Avoidance, Protection Protection Decontamination	Lightweight Detection Equipment (CAM, Mini-Detector, CADNET) Simplified Collective Protection Equipment Lightweight Decontamination System Dual-Purpose Smoke Generator/ Decontamination System Generic Detection of Chemical/Biological Agents
Army Research Office	Power Extraction (High-T Operation) Advanced Composites	Combustion in Engines Lightweight Structural Materials (Bearingless Main Rotor Blade)
	Performance Derived Trade-Offs	Rotor Performance
Atmospheric Science Laboratory	MDS	Artillery Meteorology (Met Data System, Windfinder, Profiler)
Ballistic Research Laboratory	Structures	Composite Structure Program, Light-weight Applique Armor
	Munitions	Smart Munitions, Improved Propellants, Improved Anti-Armor Warheads
	Survivability	Reduce Vulnerability/Susceptability, Logistics Modeling, Insensitive Munitions

Table A-10 cont'd

ASB - Lightening the Force, Tech Base/Opportunities

U.S. Army Laboratory/Command	Technology	Application
Electronics Technology and Devices Laboratory	Micro Electronics, Semiconductor Technology	Pocket Radiac, TD-660 Multiplexer
	Microwave and Signal Processing	MM/MMW GaAs Monolithic and Hybrid Integrated Circuits, Firefinder (AN/TPQ-37), Quicklock (ELINT), High Voltage FET Transmitters
	Integrated Device Processing and Displays	Thin Film Display Panels, Firefinder, Digital Message Device, Full Color Thin Film Display Panel
	Power Source	High Rate, High Energy Throwaway Batteries, for DMD, High Energy Multicapable Batteries
Vulnerability Assessment Laboratory	Special EMI/High Power Microwave	EW
	Unintended Radiated Emissions/ Signature	EW
Harry Diamond Laboratories	Artillery Delivered Expendable Jammer	XM867 ECM Projectile
	D.C. Power Generation	Portable Generator (Big Foot)
	Opto-Hydraulic Servovalve	Digital Optical Control Center
	UAV Borne Radar	Division Area Sensor System (Division Level Bistatic)
	Artillery Fuse Evolution	Artillery Fuses
Material Technology Laboratory	Ceramic Engine Technology	Advanced Engine Design
	Ceramic Armor	AFV
	Thick Structural Composites	Ground Combat Vehicles
Engineer Topographic Laboratories	Digital Image Processing	Image Processing Dissemination System
	Electronics	Single-Crystal CRT, Quick Response Multicolor Printer, Computer Image Generation of Terrain

Table A-10 cont'd

ASB - Lightening the Force, Tech Base/Opportunities

U.S. Army Laboratory/Command	Technology	Application
	Laser Optical Disc	Digital Topographic Support Systems
Belvoir RDEC Logistic Support Directorate	High-Tech Reverse Osmosis Water Purification	Water Purification Unit
	Self-Deployable Logistics Vehicles	Assault Bridges
Corps of Engineers	Topographic Techniques	Digital Topographic Support System
	Exploitation of the Battlefield Environment	Tactical Decision Aids, Counter-Mobility, Weapons System Performance, Aviation, NBC
	Logistics	Bridging, Over the Shore Delivery, Repair of Communications Lines
	Demolitions	Penetration Augmented Munition, Bridge and Road Munition, Rapid Lightweight Shallow Drilling Capability
Office of the Surgeon General	Medical Oxygen	Field Medical Oxygen Generating and Distribution System
	Resuscitative Fluids	Resuscitative Fluids Production and Reconstitution System
	X-Ray	High Capacity X-Ray
	Saline Solution	Hypertonic Saline
	Vaccines	Prevention of Infectious Diseases in BW
Natick RDE Center	Rations and Food Delivery Systems	Food Packet, Field Bakery, Water Purification
	Materials/Weave, Composite A-900	Ballistic Vest, Ballistic Helmet
	Design/Materials	Extended Cold Weather Systems, Cold Weather Boot, NBC Oversuit
Human Engineering Laboratory	Soldier Performance Enhancement	Basic Weapon Issue, Selected Munitions
	Battlefield Sustainment, Nutrition	Selected Mission Equipment, Rations

Table A-10 cont'd

ASB - Lightening the Force, Tech Base/Opportunities

U.S. Army Laboratory/Command	Technology	Application
Tank-Automotive Command RDE Center	High Temperature Materials, Tribology, Advanced Heat Exchangers, Advanced Sensors	Mobility-Ground Combat Vehicle
	VHSIC, VLSI, Solid State Switches, Mass Storage	Vehicle Electronics
	Ceramic/Composite Materials, MM Wave and Laser Radar Sensing Systems, Tailored Explosives	Survivability
	Video Communications, Multiple Vehicle Command & Control, Navigation, Sensors	Robotics
	Super Computer Based Dynamic Analyses of Flexible Bodies, Finite Element Analysis Physical Simulation Techniques	Simulation
Communications-Electronics Command	Field Effect Transistor Structure	TACJAM (AN/MLQ-34) AN/TLQ-17, HEXJAM Artillery Emplaced Jammers
	Uncooled Infrared (IR) Technology	Short Range Thermal Sight (SRTS) Advanced Combat Rifle Sight (ACRS)
	Thermoelectrically Cooled Hybrid Focal Plane Array	Thermal Weapon Sights
	Fiber Optics	Long Haul, LAN, FOG-M, Internal Wiring
Missile Command RDE Center	Multi-Purpose Individual Munitions	Shoulder Launched or Rifle Launched Munition
	Fiber Optic Guided Missile	Forward Area Air Defense (FAAD) -Not Line of Sight (NLOS)
	(-)	(Setter) FAAD-LOS-R
	(-)	Advanced Anti Tank Weapon System - Medium
	(-)	Light Artillery Rocket System (LARS)
	(-)	Teleoperated Mobile Antiarmor Platform (TMAP)

Table A-10 cont'd

ASB - Lightening the Force, Tech Base/Opportunities

U.S. Army Laboratory/Command	Technology	Application
Aviation Systems Command	Reduced Fuel Consumption (-)	Army/Navy Demo Engine (D44706) Multi-purpose Small Power Unit - AVSCOM/ TACOM/BRDC (D44702) Engine 21 - Army/ Navy (D44707)
	Artificial Intelligence, Decon-tamination, (-)	Ground Support Equipment - Diagnostics, Decontamination/Deicing, Boresight Equipment
	Advanced Structures	Battle Damage Repair
	Materials	Cargo System Components
	Navigation	Mini-Global Positioning System (GPS)
DARPA/Army/Marines	Armor/Antiarmor Program Reactive/Semiactive, Ceramics, Advanced Metals, Polymer Composites, Fabrication Technology, Materials Processing, Armor Payoff Assessment, Signature Reduction, EM Guns, CE Warheads, KE Warheads	Ground Combat Vehicles

Table A-11
Key Drivers to Lighten the Force

		Technology Level*	Issues Affected
1.	Radio and Battery Weight	N	3
2.	Digital Components	M-F	3,5,6
3.	POL Consumption	N	3
4.	Engine/Transmission (Fuel Efficiency)	N-M	4
5.	AFV (Armored Family of Vehicles)	M	4
6.	Helicopters/AC	M	4
7.	UAV (Unmanned Aerial Vehicles)	N-M	4
8.	Armor		
	(a) Passive	N	4
	(b) Ceramic	N-M	4,6
	(c) Reactive	N-M	4,6
	(d) Active	F	6
9.	Ammunition/Packaging	N-M	4,5
10.	Smart Weapons	M-F	5,6
11.	ATR (Automatic Target Recognition)	M-F	5,6
12.	Diagnostics/Prognostics	M-F	3,5,6
13.	Mine Detection	M-F	4,6
14.	Composites	N-M	4,6
15.	Conducting Polymers	M-F	6
16.	Robotics		
	(a) Teleoperated/Crew Assist	N-M	4,6
	(b) Autonomous	M-F	6
17.	HVM (Hypervelocity Missile)	M-F	4,6
18.	LP (Liquid Propellant Gun)	M-F	4
19.	Electrical Weapons	M-F	6
20.	Superconductivity	F	6
21.	Compact Power Generation	M-F	4,6

* Technology Levels: N, Near-Term, Technology and Engineering Available; M, Mid-Term, Technology Available, Engineering Required; F, Far-Term, Technology and Engineering Required

Table A-12

Attributes of EM Guns

Pro

Reduced muzzle blast
High muzzle velocities
Reduced recoil
Reduced expendables
Propellant commonality (JP-8)

Con

Prime power noise and size
Electrical signature

A conceptual diagram of the LP gun chamber is shown in Figure 2.

Comparison of propellant volumes required by conventional (not including dunnage), LP, and EM guns for equal energy into the projectile are given in Table A-13 below. The EM gun uses JP-8 as the propellant (i.e., power generation).

Table A-13

Comparison of Propellants

	Impetus (joules/cm3)	Conversion Efficiency (%)	Volume Ratio
Conventional	1,070	27	1.00
LP	1,434	27	0.75
EM (JP-8)	10,000	6	0.43

Volume comparisons of conventional solid vs. EM vs. LP are shown in Figure 3.

The concept of operation of the ET gun is shown in Figure 4, another form of electrical weapon in development. Additional electrically powered weapons include lasers and high powered microwaves, as well as particle beams.

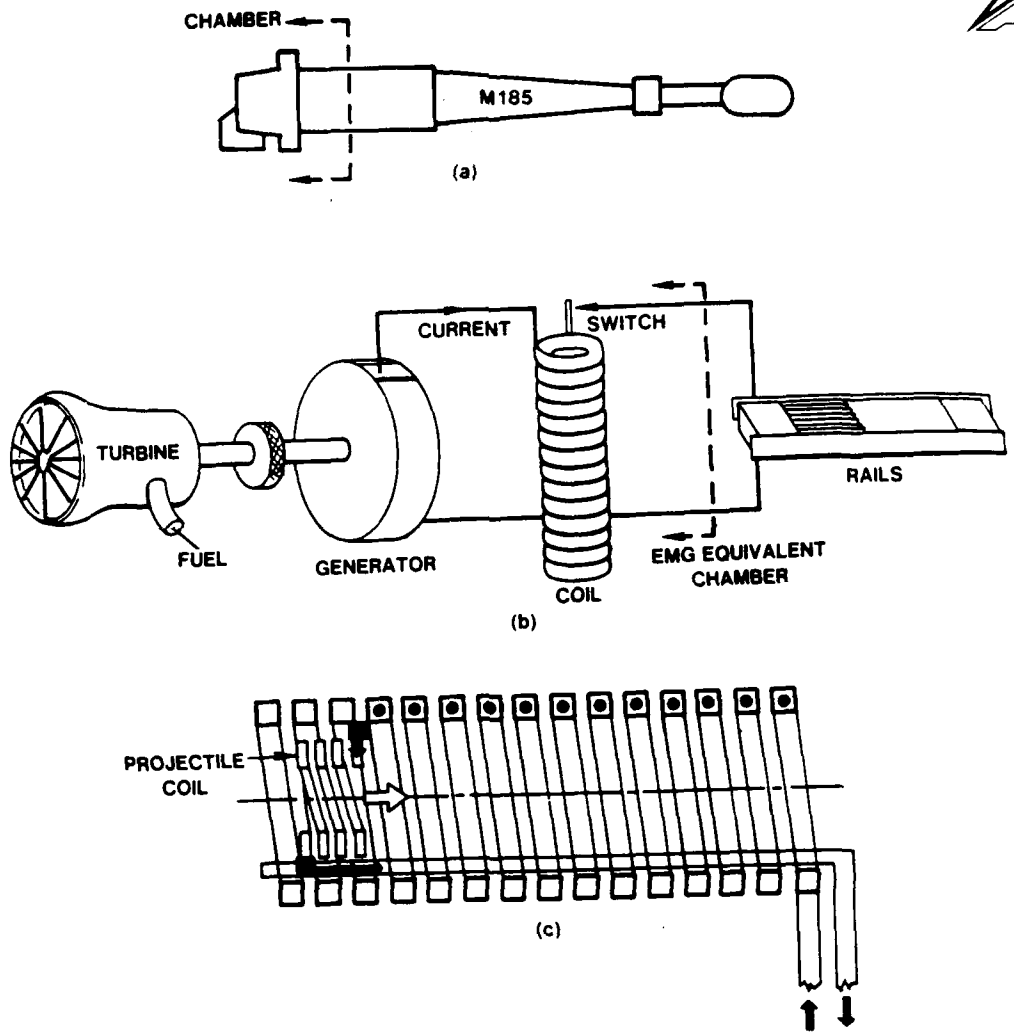

FIGURE 1

CONVENTIONAL AND ELECTROMAGNETIC GUNS

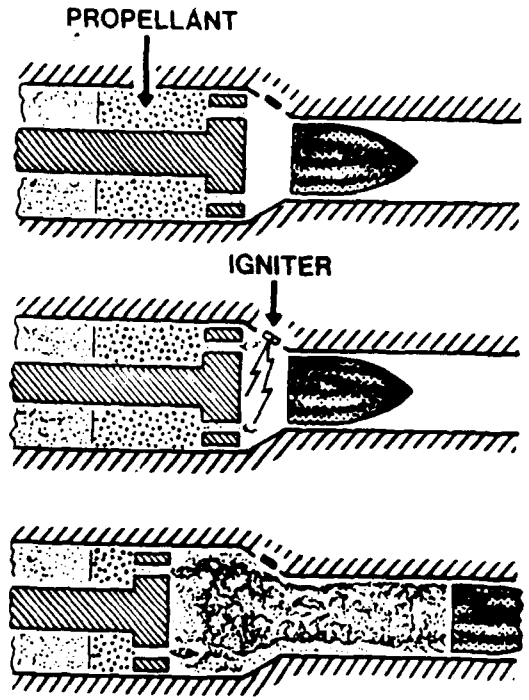

FIGURE 2

REGENERATIVE LIQUID PROPELLANT GUN

CONVENTIONAL SOLID VS. EM VS. LIQUID

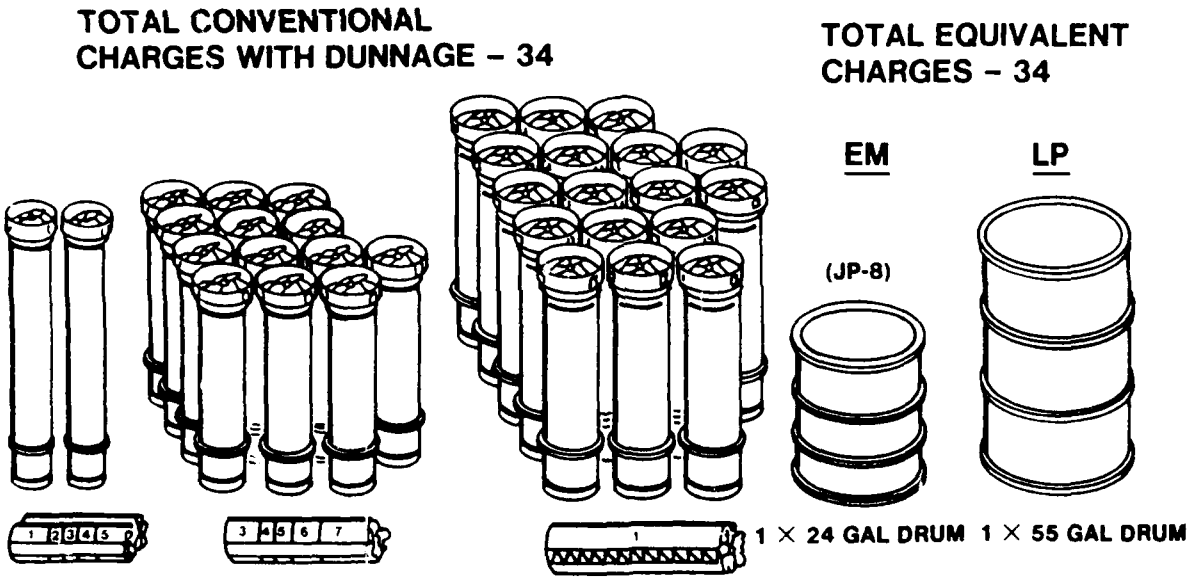

FIGURE 3

M109A BASIC LOADS

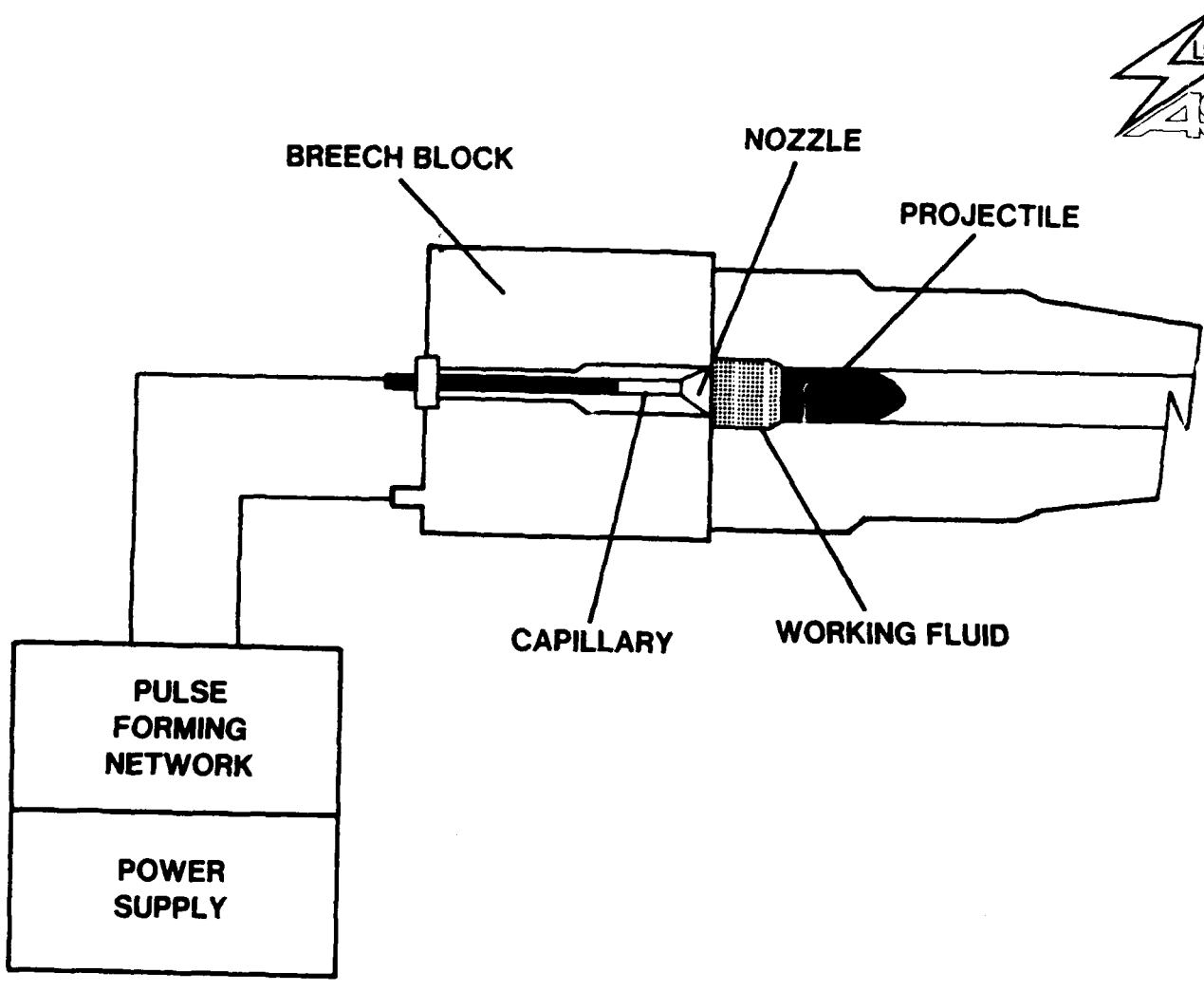

FIGURE 4
ELECTROTHERMAL TECHNOLOGY

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APPENDIX G

GLOSSARY OF TERMS

ADEA	Army Development and Employment Agency
AFV	Army Family of Vehicles
AIPS	Advanced Integrated Propulsion System
AMSAA	Army Materiel Systems Analysis Agency
ARDEC	Armament Research, Development and Engineering Center
ASB	Army Science Board
ATM	Anti-Tactical Missile
ATR	Automatic Target Recognition
AVSCOM	Aviation Systems Command
BDP	Battlefield Deficiency Plan
BRDEC	Belvoir Research, Development and Engineering Center
CAA	Concepts Analysis Agency
CECOM	Communications-Electronics Command
CNVEO	Center for Night Vision and Electro-Optics
COE	Corps of Engineers
CSA	Chief of Staff, Army
CSS	Combat Service Support
DA	Department of Army
DARPA	Defense Advanced Research Projects Agency
DCSRDA	Deputy Chief of Staff for Research, Development and Acquisition
EM	Electro-Magnetic
EML	Electro-Magnetic Launch
ET	Electro-Thermal
FASTALS	Field Artillery Simulation Theater Army Logistics Support
FLOT	Forward Line of Our Troops
HMMWV	High Mobility Multipurpose Wheeled Vehicle
HPM	High Power Microwave
HQDA	Headquarters Department of the Army
HTTB	High Technology Test Bed

ID	Infantry Division
IDF	Israeli Defense Force
JCS	Joint Chiefs of Staff
JPAM/POM	Joint Program Assessment Memorandum/Program Objective Memorandum
JTACMS	Joint Service Target Attack Radar System
LABCOM	Laboratory Command
LHX	Light Helicopter Experimental
LID	Light Infantry Division
LP	Liquid Propellant
LRRDAP	Long Range Research and Development Plan
LTF	Lightening the Force
MAA	Mission Area Analysis
MICOM	Missile Command
MLRS	Multiple Launch Rocket System
MPLH	Multipurpose Light Helicopter
MTBF	Mean Time Between Failure
NASA	National Aeronautics and Space Administration
NDI	Nondevelopmental Item
O&O	Operational and Organizational
ODCSLOG	Office of the Deputy Chief of Staff for Logistics
P3I	Pre-planned Product Improvement
PGM	Precision Guided Munitions
POL	Petroleum, Oil and Lubricants
QRP	Quick Reaction Program
R&D	Research and Development
RDA	Research, Development and Acquisition
RSTA	Reconnaissance, Surveillance and Target Acquisition

SADARM	Sense and Destroy Armor Munition
SINCGARS	Single Channel Ground and Airborne Radio System
S.	Self Propelled
TACOM	Tank-Automotive Command
TDT	Target Discrimination Technology
TMDE	Test, Measurement and Diagnostic Equipment
TOW	Tube-Launched, Optically Tracked, Wire Command-Link Guided
TRAC	TRADOC Analysis Command
TRADOC	Training and Doctrine Command
UAV	Unmanned Aerial Vehicle

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