DEPARTMENT OF THE ARMY
U.S. ARMY MEDICAL RESEARCH AND MATERIEL COMMAND
FORT DETRICK, FREDERICK, MD 21702-5012

REPLY TO
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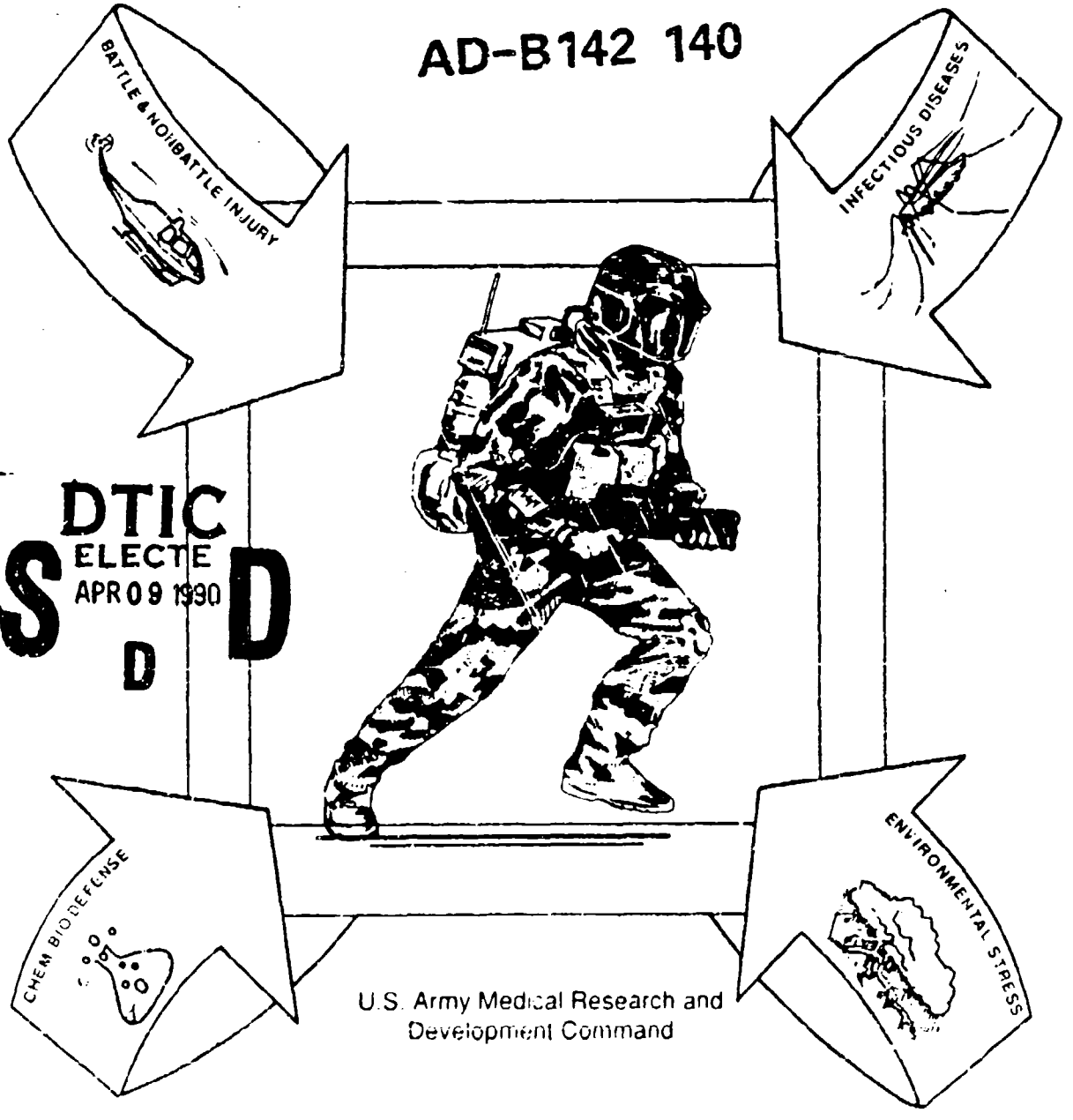
Medical Technology Base Master Plan

March 1990



U.S. Army Medical Research and Development Command

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The Medical Technology Base Master Plan describes the overall U.S. Army Medical Research and Development Command (USAMRDC) investment strategy and program approach including: 1) the operating principles and mechanisms of the medical R&D program; 2) the current status of the medical technology base program; and 3) an assessment of issues and future challenges that may impact the planning, programming, execution, viability and responsiveness of the biomedical technology base effort and overall medical R&D program.

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MEDICAL TECHNOLOGY BASE MASTER PLAN

March 1990

U.S. Army Medical Research and Development Command

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

14 March 1990

The U.S. Army Medical Research and Development Command (USAMRDC) fully embraces the spirit of the Army Technology Base Master Plan (ATBMP) with publication of the Medical Technology Base Master Plan (MTBMP). The MTBMP clearly ties together the Army's key existing and emerging medical technologies together with mission-oriented medical requirements. It also provides the top-down guidance necessary for management to effectively and efficiently focus program resources on the highest priority current and future threats.

Now, more than ever before, we are challenged to increase our productivity in an environment of declining resources. To meet this challenge, we must maintain and enhance the vitality of the Army's long term technology base by utilizing the most efficient investment strategy possible. In this connection, implementation of the investment strategy described in the MTBMP demands close coordination of people and projects across technologies within the USAMRDC, as well as exploitation of civilian and foreign medical technologies as a "force multiplier" for the Army's most valuable and vulnerable resource - The Soldier.

Successful exploitation of emerging technology for application to the Army's most pressing needs requires the rapid insertion of technological advances into new products. The Army Science Board has identified this requirement as absolutely critical to the Army's ability to preserve its technological superiority. To ensure this requirement is met, the MTBMP outlines a systematic approach to demonstration and insertion of new technologies in the process of transition from basic research to product development

I commend the efforts of the USAMRDC and the Office of The Surgeon General in formulating this clearly delineated plan for coherent management of our medical technology base. It represents an outstanding point of departure for the biomedical research required to fulfill the military medical requirements of the 21st century.

Stephen K. Conver
Assistant Secretary of the Army
(Research, Development and Acquisition)

DEPARTMENT OF THE ARMY
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9109 LEESBURG PIKE
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REPLY TO
ATTENTION OF

19 March 1990

The Medical Technology Base Master Plan (MTBMP) provides the technological and managerial foundation required for development of next generation and future medical materiel and information products. The MTBMP logically extends the goals and objectives of the Army Technology Base Master Plan and provides the blueprint required to focus and coordinate the Army's research on those technologies needed to address critical military medical requirements. It is the first document of its kind to be published, thereby, fulfilling a critical need for providing the coherent "top-down" guidance required to concentrate the Army medical research program efforts on the ever-proliferating variety of threats while matching program requirements with increasingly declining resources.

The spectrum of threats for the future battlefield include a diverse range of disabling and deadly toxic agents, lethal weapons systems, occupational health hazards and environmental extremes. Soldiers face the threats of biological warfare organisms and toxins, directed energy weapons, and a wider variety of chemical warfare agents in addition to the ever-present threats of endemic infectious diseases, conventional weapons and environmental extremes. The increasingly lethal and complex battlefield of AirLand Battle Future also presents extraordinary psychological challenges to the soldier; these must be overcome to sustain an effective fighting force. The research programs of the U.S. Army Medical Research and Development Command (USAMRDC) are focused heavily on the prevention of casualties; these efforts contribute significantly to the readiness and sustainment of the Army's warfighting capability, as well as to a significant reduction in the number of casualties reaching the Army Medical Department's (AMEDD) overburdened medical treatment facilities. No one knows precisely what threats will be faced in the next conflict, but history suggests that victory will depend heavily on the presence of a superior medical technology base that can respond rapidly with required countermeasures to emerging health threats as shown in the MTBMP. The USAMRDC laboratories provide the capability to solve the medical problems of the future battlefield through the efforts of internationally renowned medical and scientific experts working in state-of-the-art facilities and in the field. The MTBMP provides a framework for the efficient coordination of these experts' efforts and for the application and augmentation of

their capabilities by leveraging the research investments made by industry, academia, our Allies and other U.S. government organizations.

The MTBMP is the result of an intensive effort which required close coordination among my office, USAMRDC headquarters, USAMRDC laboratories and Army Combat and Materiel Developers of medical products. Because it is a living document, it must under go continual evaluation and periodic revision in order to remain responsive in the face of evolving military requirements and biomedical technologies. I enthusiastically support this landmark effort by the U.S. Army Medical Research and Development Community to plan effectively to meet its challenges both today and tomorrow through its programs of "Research for the Soldier" and thus, better realizing the AMEDD goal to "preserve the Fighting Strength."

Frank Ledford

Frank F. Ledford, Jr.
Lieutenant General
The Surgeon General

PREFACE

Soldiers and Commanders of the military forces of the United States now face a more demanding set of challenges than in past decades: 1) more potential adversaries, having better equipped and more effective forces; 2) the possibility of conflicts occurring over a wider geographic domain, exposing forces to the threat of a greater number and diversity of diseases and more varied environmental conditions; and 3) new weapons and technologies in addition to more effective versions of those fielded in the past. To counter these challenges, we must raise our present level of preparedness -- a goal that is challenged by constrained economic and manpower resources.

The requisite level of preparedness is founded on a strong technology base which focuses on future warfighting needs. The key to a focussed and stable technology base is a sound investment strategy. The Department of the Army's overall Technology Base Investment Strategy (TBIS), as documented in the Army Technology Base Master Plan (ATBMP - April 1989), provides for preservation of preeminent military capability through maintenance of technological superiority.

The U.S. Army Medical Research and Development Command (USAMRDC) must continue to maintain its technology base program at the forefront of biomedical science and technology. Through medical research and development (R&D) products, including both materiel and nonmateriel solutions, USAMRDC directly supports the most complex and irreplaceable of all Army systems -- the soldier. Unless a vigorous biomedical science and technology base effort is maintained, we risk losing our ability to protect our soldiers and, ultimately, to successfully respond to the imperatives of national defense. In concert with the ATBMP, this Medical Technology Base Master Plan (MTBMP) describes the overall USAMRDC investment strategy and program approach: 1) the operating principles and mechanisms of the medical R&D program; 2) the current status of the medical technology base program; and 3) an assessment of issues and future challenges that may impact the planning, programming, execution, viability, and responsiveness of the biomedical technology base effort and overall medical R&D program.

Medical R&D products are crucial to the Army's mission, and the Army has a distinguished record of responding to this need. For evidence, one need only scan the historical account of remarkable accomplishment detailed in Section II. The military's medical R&D role in support of mobilization and training, deployment, sustainment, and modernization is well documented. The medical problems encountered in the past -- yellow fever, malaria, mustard gas, and climatic injuries, to name a few -- had profound effects on the military theaters in which they occurred. Every campaign has been confronted by medical problems; far more often than not, the victor was the army which mastered those problems through the efforts of biomedical scientists and health care practitioners, and the medical materiel, information and procedures their expertise made possible. We cannot be certain exactly what medical challenges lie ahead, but history warns us that there will be challenges of this class, and we must maintain the capability to respond rapidly with appropriate medical countermeasures.

Medical products developed by the military often lead to benefits for the civilian population and transfer of technology from the civilian medical research and development establishment is leveraged. However, there are many medical problems today that primarily concern military personnel; these include battlefield combat casualty care, chemical and biological defense, infectious diseases not endemic to the United States, directed energy protection, and health hazards from weapon system operations and environmental extremes. There is little incentive for industry to provide products addressing these problems; matters of primarily military concern have limited economic appeal in the civilian sector. Moreover, the nonmilitary government sector lacks the all-important element -- knowledge of fighting requirements -- to shape these products to the needs of the battlefield environment. Without knowledge of military missions, these programs address civilian needs, leaving the Army and the USAMRDC the appropriate venue for military medical research.

Contents of the Medical Technology Base Master Plan

Section I introduces the medical technology base, describes the medical research and development process and the focus of technology base components.

Section II puts medical R&D in perspective by presenting a history of the development of Army medical research and a synopsis of the warfighting payoffs from investment in military medical R&D. Lessons learned throughout history clearly demonstrate the importance of effectively anticipating, preparing for, and responding to military threats. Materiel and information products resulting from Army medical research and development have produced cost savings as well as sustained and augmented combat and non-combat mission effectiveness. Examples of the Army's return on investment in medical R&D, past and projected, are presented in this section.

Section III presents an overview of influences on medical R&D planning and programming. To maintain adequate capabilities for deterrence and defense in the face of a changing global threat environment, the Army must plan for the future, properly program, and allocate funding. To do this, the Army must determine which technologies to acquire, develop, or forego; adjust its organization and doctrine; train its personnel for the future battlefield; and ultimately, satisfy the requirements of combat Commanders. Program planning influences outlined in Section III include: worldwide trends and influences; military and natural health threats; long-range planning guidance; the Concept-Based Requirements System (CBRS); as well as the Planning, Programming, Budgeting, and Execution System (PPBES). These influences and processes provide the foundation for the 21st century, not only for Total Army Goals and objectives, but each of its missions including that of the Army Medical Department (AMEDD). Additionally, Section III describes the sources of Army requirements that impinge on program development. Supplementing the Army's requirements are descriptions of other influences that impact on medical R&D program development; i.e., Joint Service requirements, international agreements, domestic politics, public opinion, and regulatory requirements.

Section IV addresses the Army Technology Base Investment Strategy (TBIS) which provides a focus for 6.1, 6.2 and 6.3A research. The Army's TBIS is designed to provide the Army warfighting capability across the full spectrum of conflict; the medical TBIS implements and supports the Army TBIS. This section describes the medical R&D investment strategies that will be used to implement the goals and objectives contained in the ATBMP and MTBMP. In addition, research thrusts and issues upon which the medical technology base community will focus over the next 20 years are presented. The section concludes with a discussion on funding projections and leveraging.

Section V describes the organizational framework that ensures involvement of the scientific and management staff of the USAMRDC in every phase of the R&D process, from the identification of problems to the provision of effective solutions. Key management policies, procedures and mechanisms important to the fielding of operationally useful products in a timely and cost-effective manner are discussed. The matrix management mechanism involving continuous dialogue and coordination among scientists and managers, Research Area Directors (RADs) and Commanders, and the various staff elements throughout the Department of Defense (DoD) is presented.

Section VI presents a detailed look at the medical R&D program areas. This section of the MTBMP outlines how the USAMRDC intends to provide solutions to Army requirements and thus contributes to enhanced warfighting capability across the full spectrum of conflict by: 1) presenting the "drivers" of the current program, 2) presenting the current mission, goals, and objectives of each of the research areas; 3) identifying the primary DoD laboratories that are associated with the research areas and identifying their research emphases; 4) presenting the requirements and guidance to be addressed, including threat, countermeasures, and technical barriers to the countermeasures within each research area; and,

5) projecting budget requirements through Fiscal Year 1996. Following the discussion of the research program areas is a description of the technical barriers faced by the program areas and the research needed to address these barriers. This section culminates with a discussion of future directions which includes a long-range vision of those medical requirements where the USAMRDC can contribute to conserve the fighting strength of our soldiers and simultaneously meet our country's national and strategic objectives into the 21st century.

Materiel and non-materiel products provided by the AMEDD are of paramount importance as enablers of the Army's basic warfighting capabilities. Given that the soldier is, and will remain, the most important warfighting system, it is essential that medical R&D continue to support the Army's mission capabilities. This MTBMP provides the guidance and strategy necessary to plan, program, and execute an effective program of RESEARCH FOR THE SOLDIER.

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Section I

THE ARMY MEDICAL TECHNOLOGY BASE

INTRODUCTION

The U.S. Army Medical Research and Development Command (USAMRDC) has a challenging and critical mission: to discover, design and develop military medical countermeasures against threats to health of military personnel. The soldier is the Army's most valuable and vulnerable system. Maintenance of this warfighting asset is critical to our security. The spectrum of military threats to our national security is presently undergoing significant change, and the requirements for medical countermeasures change in concert. Few threats seem to go away, and new ones compete for countermeasure research and development (R&D) dollars. The optimum use of technology is critical to maintaining military capability. Whereas Commander-in-Chiefs (CINCs) and combat developers decide what warfighting capabilities are needed, it is the role of R&D agencies (i.e., Materiel Developers) to identify what capabilities can be achieved and how best to achieve them. In a general sense, provision of improved or novel capabilities requires both invention and innovation to produce new options and implementation of solutions those options make possible. The USAMRDC, responsible for developing both medical materiel and informational solutions, must ensure that a state-of-the-art science and technology base is maintained and responsibly applied to ensure an effective and efficient response to identified needs.

Within this technology base program, priorities and command guidance are highly threat-driven and must respond to and support the Concept-Based Requirements System (CBRS). To accommodate these "drivers" the medical technology base program must maintain a broad flexibility in core scientific skills, personnel and facilities. The USAMRDC works closely with the Office of the Assistant Secretary of the Army for Research Development and Acquisition [OASA (RDA)], other Department of Defense (DoD) and Federal agencies, industry, academia, and foreign sources to ensure that a strong and responsive biomedical science and technology base is maintained. Figure I-1 displays selected examples of the internal and external influences on the medical R&D process.

MEDICAL TECHNOLOGY BASE CATEGORIES

DoD funding for R&D is programmatically divided into functional categories that progress from inventive to implementive. In general, efforts categorized as Research (6.1) or Exploratory Development (6.2) are part of the inventive process, and those categorized as Non-Systems Advanced Development (6.3A), Systems Advanced Development (6.3B), or Full-Scale Development (6.4) may be inventive and/or implementive. The identifiers 6.1, 6.2, etc., also are used in apportioning funds. In the Army's R&D scheme, the 6.1, 6.2 and 6.3A categories are collectively known as the "tech base."

These categories and the phases of R&D they support are used in all DoD R&D programs. However, there are several key differences among the medical R&D phasing plans and funding profiles and most other military (and non-military) R&D programs. Medical products, particularly drugs and vaccines, often have a longer life as identifiable candidates in the R&D cycle than do non-medical ones, and the relative investment in the technology base, as compared to development, is greater for medical programs than for many non-medical programs. The extended total R&D time for these medical products is balanced by the fact that they are available for "contingency fielding," available to fulfill defense needs under a test plan approved by the Food and Drug Administration (FDA), at a much earlier stage than non-medical systems. The factors listed below contribute to the apparent differences.

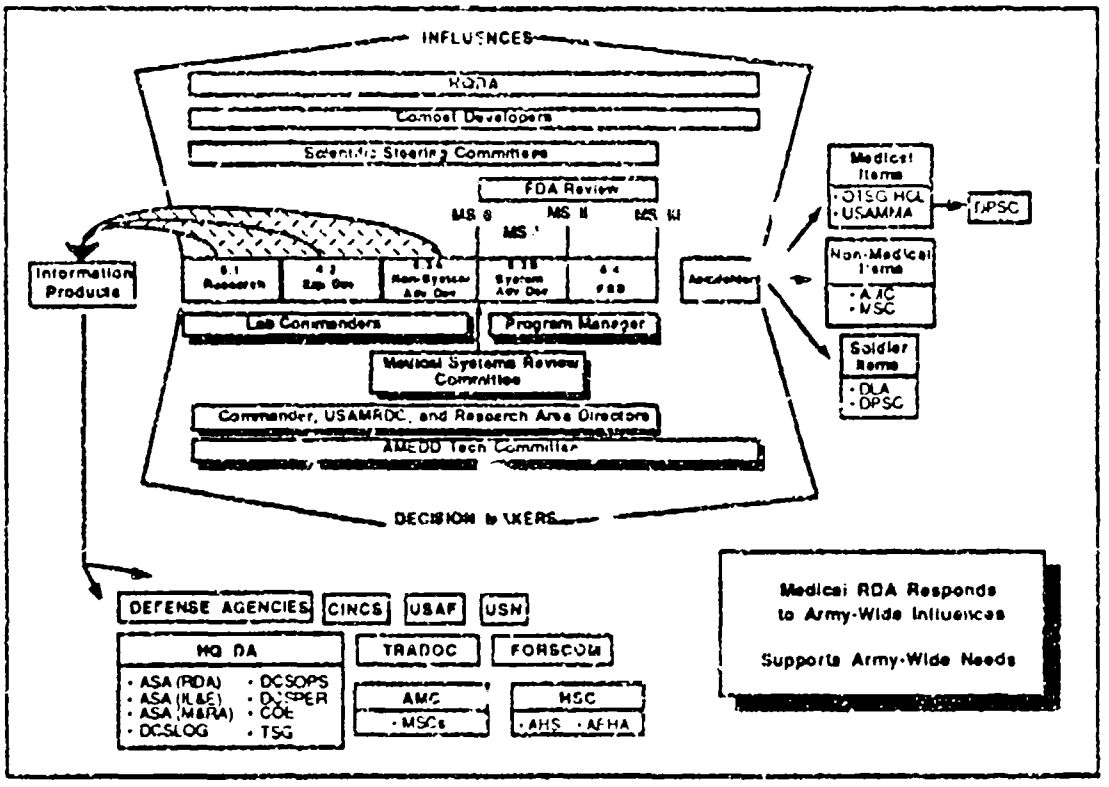


Figure 1-1. Influences on Army Medical R&D

- Many medical products, primarily drugs, attain a greater degree of conceptual maturity before passing to development (6.3B) than do non-medical systems. This disparity is due primarily to the influence of the FDA approval process on the Army's Materiel Acquisition Decision Process. The expenditure of management and technical resources required by the FDA process favor retaining candidate products in the technology base until safety and efficacy are sufficient to reasonably assure chances of approval for human trials.

- The human efficacy and safety phases of drug and vaccine development are particularly characterized by increasing costs industry-wide and, since the outbreak of disease necessary for clinical trials cannot be scheduled, uncontrollable delays in testing. These factors are balanced by the fact that much of the cost typical of the clinical testing phases of pharmaceutical and biological development is shared with industry and other countries.

- The many informational or non-materiel contributions of medical R&D needed to support the Army's warfighting missions require comparatively greater total investment in the technology base than programs oriented largely to support only system development.

Figure 1-2 portrays the phases of medical R&D for the 6.1-6.4 structure. These categories are defined below and examples of the types of biomedical work supported within each category are included.

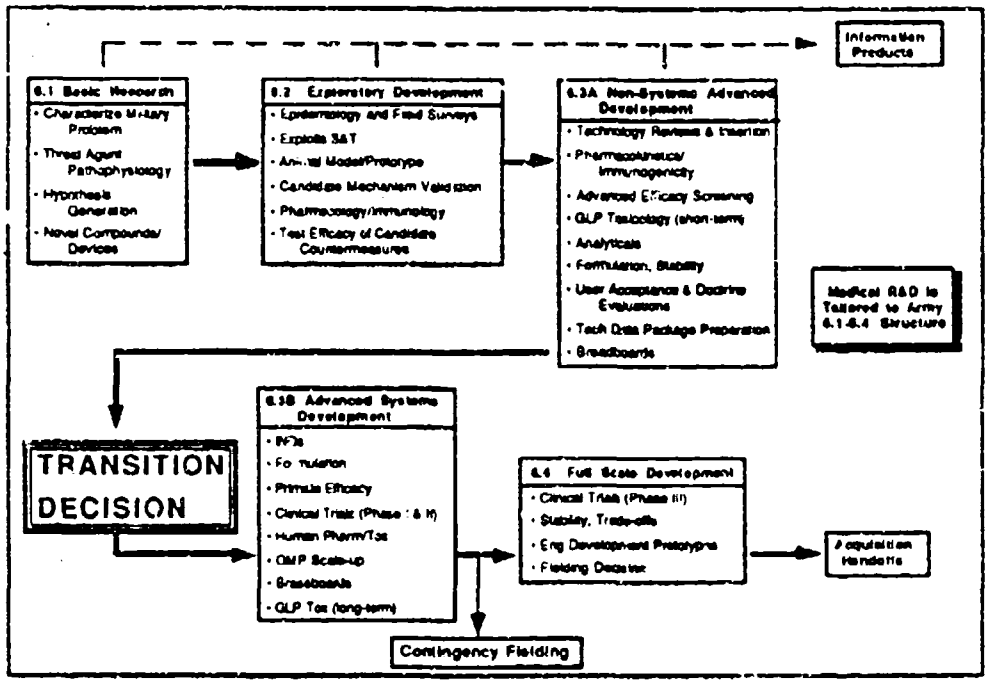


Figure I-2. Phases of Medical R&D

Basic Research (6.1)

The Basic Research (6.1) component of medical R&D increases knowledge and understanding in those fields of the biomedical, environmental, neuroscience, and behavioral sciences related to long-term national security needs. The information provided is necessary for the solution of identified military problems through innovation in training and doctrine, as well as for subsequent exploratory and advanced development of materiel. A significant goal of 6.1 research is the maintenance of sufficient technological expertise to avoid technological surprise and to sustain the capability to rapidly deal with future requirements. Sources for such expertise include military laboratories, industry, academic institutions, and other Government agencies. In addition, USAMRDC scientific personnel maintain close liaison with counterparts in other nations. Examples of the USAMRDC's 6.1 research are provided in Figure I-3.

- Delineation of the mechanisms and sites of action of chemical and biological threat agents
- The isolation, identification, and characterization of militarily relevant microorganisms
- Laboratory-scale synthesis of new compounds (<2 gm)
- Studies of structure-activity relationships
- Establishment of the biomedical data base needed to identify conceptual countermeasures to military health threats
- Comparative study of new and well-characterized disease-producing organisms
- Fundamental studies of the physiological and psychological demands of soldier performance

Figure I-3. Examples of Biomedical Basic Research (6.1)

Exploratory Development (6.2)

Exploratory Development (6.2) is directed at establishing the feasibility of solutions to specific, but perhaps broadly defined, military problems. In this phase, research data acquired in earlier studies are used in developing laboratory models for studying health threats, in synthesizing and studying candidate therapeutic agents, and in initial screening of candidate compounds for efficacy and toxicity. This category also supports preliminary development of processes and methodologies that support the acquisition process (e.g., novel production technology, laboratory models, simulations, and assessment technology). Examples of biomedical research in the 6.2 phase are presented in Figure I-4.

- Laboratory synthesis of candidate pretreatment, prophylactic and therapeutic compounds (<50 gm) by conventional and biotechnological procedures
- Initial development of *in vitro* and *in vivo* models for use in efficacy and toxicity screening and in studies of the pathogenesis and pathophysiology of health threats
- Primary and secondary screening studies of the efficacy of candidate medical countermeasures
- Applied (i.e., clinical or field) studies of the pathogenesis, pathophysiology, natural history, and geographic distribution of military health threats
- Definition of the sites and mechanisms of action of candidate medical countermeasures
- Analysis and characterization of candidate compounds and their metabolites
- Application of molecular manipulation techniques in enhancing the efficacy and/or decreasing the toxicity of candidate countermeasures
- Preliminary toxicity screening studies
- Exploitation of emerging technologies for developing product concepts

Figure I-4. Examples of Biomedical Exploratory Development (6.2)

Advanced Development (6.3)

In Advanced Development (6.3), the goal is "proof of principle" (i.e., proof of the viability of system or concept). Efforts in this category are directed toward the solution of identified deficiencies. Both materiel and nonmateriel candidate solutions may be assessed for technical maturity using laboratory and/or field (e.g., clinical) tests. Advanced Development is divided into two categories, 6.3A and 6.3B.

Non-Systems Advanced Development (6.3A). This category is primarily directed at demonstrating the feasibility of materiel solutions and the validity of nonmateriel solutions. Category 6.3A research provides information that reduces uncertainties and technical risk, avoids costly false starts in formal development programs, and ensures timely insertion of the most up-to-date technology into developmental systems. It also provides data essential to the preparation of Operational and Organizational (O&O) plans. These O&O plans describe how and where a product or system will be integrated into the force structure, deployed, operated and supported in peace and war; they are the "gatekeepers" that accompany transition to 6.3B, the initial phase of development.

The technology demonstrations typical of this category may test operational utility as well as technical feasibility. The term "non-systems" refers to the fact that these technological demonstrations often address components, subsystems, or technology advances that have potential application to a variety of similar generic end products rather than to one specific, well-defined system (see Figure I-5). A sub-category, the Advanced Technology Transition Demonstrations (ATTDs), is discussed in Section IV.

- Synthesis of compounds (<2 kg) under Good Manufacturing Practices (GMP) for use in preclinical testing
- Advanced screening for *in vitro* and *in vivo* efficacy and toxicity of candidates for transition
- Advanced preclinical pharmacology studies (absorption, distribution, pharmacokinetics, and behavioral)
- Pre-formulation studies (physical-chemical properties)
- Assessment and validation of models, assays, assessment techniques, and manufacturing technologies prior to adoption or transition
- Test efficacy of physiological and psychological countermeasures to military unique problems
- Field demonstrations of changes to doctrine or training that improve physiological or cognitive performance

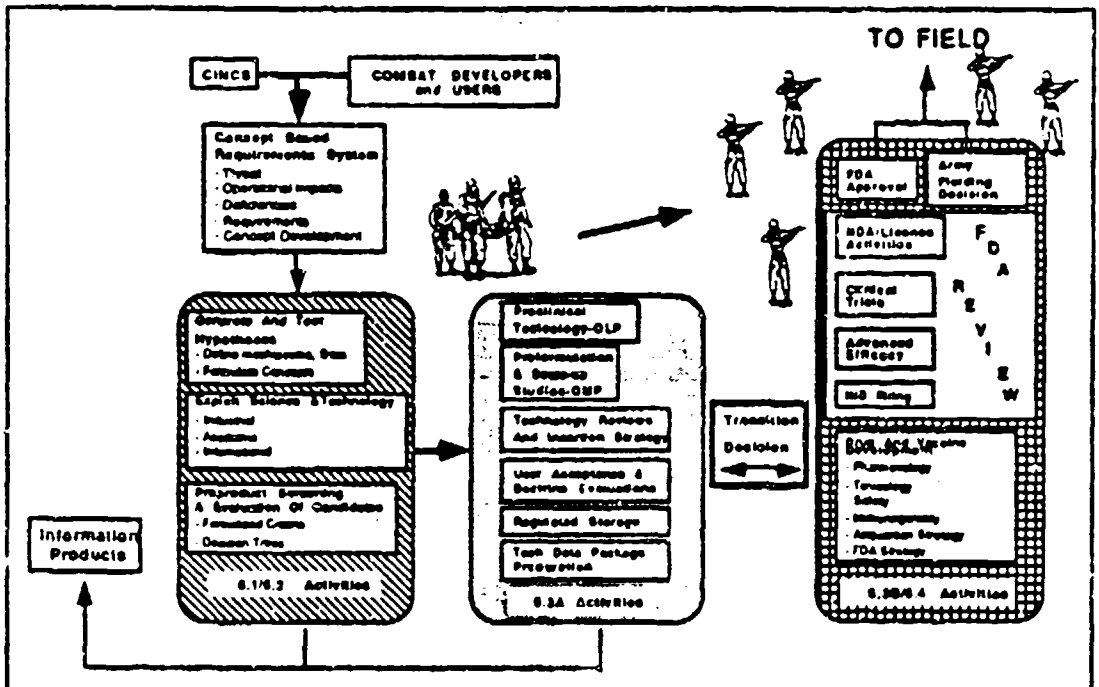
Figure I-5. Examples of Biomedical Non-systems Advanced Development (6.3A)

The major investment of the medical 6.3A category is in support of the DoD Core Drug and Vaccine Program. It is essential that only the most promising drug and vaccine candidates be selected for entry into the time-consuming and expensive process of development required by the FDA. To reduce the number of candidates entering the human trials portion of this process, the Army conducts most of the extensive battery of preclinical tests required for obtaining FDA approval for human use during 6.3A. Due to the commonality of requirements for preclinical tests among the various Joint Service program areas of medical R&D (e.g., infectious disease, chemical or biological defense), the required facilities and capabilities are jointly funded by the participating research programs and managed as an integrated Core Drug and Vaccine Program.

The current investment in this Core Drug and Vaccine Program provides the capability to collect sufficient information to make informed transition decisions [Milestone (MS) 0] on two drug and two vaccine candidates per year on the average. This is the minimum economic rate. Time required for successful candidates to pass through all phases of the Core averages approximately three years. Formal milestone schedules for individual candidates in 6.3A are unnecessary since the speed of transition is optimized through test schedules based on continual evaluation of current results. Oversight by user representatives and the Research Area Directors (RADs) of the Joint Service Programs using the Core Program ensures that high priority programmatic requirements are not sacrificed to technical expediency.

Similar Core Programs support 6.3B and 6.4 drug and vaccine development activities in the DoD industrial base. Figure I-8 summarizes these components.

Systems Advanced Development (6.3B). The goals of 6.3A and 6.3B are similar: selection of technically feasible and cost-effective solutions ("proof of principle") through demonstration and validation. The difference is that 6.3B projects must pass a Milestone 0 review and are formally entered into the initial phase of the Life Cycle System Management Model (LCSMM). This category of funding is subdivided into Concept Exploration/Definition and Demonstration/Validation phases. The Concept Exploration/Definition focuses on identification of the best options for meeting the requirements described in the O&O plan. This process typically involves trade-off analyses among several candidates, including new solutions provided by the technology base as well as "off the-shelf" solutions available in the marketplace. Concept Demonstration/Validation activities verify preliminary design and engineering concepts, establish operational goals and performance envelopes, and validate the readiness of the selected candidate for transition to 6.4, Full-Scale Development (FSD). In both phases, critical issues of logistical support and training are identified, studied, and resolved in order to minimize future risks in FSD, procurement, and fielding. Examples of 6.3B efforts are described in Figure I-7.



Industrial Base Components

- **6.3A Core Programs for Preclinical Development**
  - Minimizes time spent in technology base
  - Produces information necessary for transition decision
  - Balances in-house and extramural capabilities
  - Satisfies FDA requirements
- **6.3B Core Programs for Toxicology & Clinical Trials**
  - Supports Army Milestone I & II decisions
  - Balances in-house and extramural capabilities
  - Prepares pilot lots for clinical trials
  - Supports FDA regulatory process
- **6.4 Core Programs for Drug and Vaccine Production**
  - Supports production of contingency items
  - Establishes scale-up production procedures
  - Supports stockpile management of contingency items
  - Balances in-house and extramural capabilities
  - Supports FDA regulatory process

Sustained Investment Required

- **Specialized Capabilities Must Be Maintained**
  - Containment facilities
  - GLP toxicology/GMP manufacturing
  - Regulated storage/quality assurance
- **Successful Development Requires Continuity**
  - Start-up/shut-down is costly and time consuming

Figure 1-6. Medical R&D Drug and Vaccine Core Program

- Marketing investigations to determine the availability and utility of commercial and/or foreign products for meeting military medical requirements
- Performing long-term toxicology studies [Good Laboratory Practice (GLP)] in animals
- Pre-production studies to identify and minimize risks in large-scale production
- Pilot plant production of 3-5 kg lots of biologicals to, under GMP, demonstrate and validate process capability and reproducibility
- Preparing and submitting Investigation Exemptions for a New Drug (IND)/Investigational Device Exemptions (IDE)
- Tests [Technical Test-1 (TT-I)] of advanced development prototypes and early user tests to prove utility
- Phase I clinical pharmacology studies (safety and tolerance, pharmacokinetics, and validation of assays for compounds in biological tissues and/or fluids)
- Formulation studies (dose form, stability, etc.)
- Phase II clinical investigation studies (safety and tolerance, pharmacokinetics, efficacy, evaluation of dose and dosage form, performance screens)
- Development and assessment of initial training and supportability packages

Figure I-7. Examples of Systems Advanced Development (6.3B)

In contrast to the typical practice of competing several candidates in 6.3B, the normal practice of medical R&D is to require proof-of-principle in technology base laboratory models and subsequent selection of a single candidate for transition to development and human testing. There has never been any regulatory impediment to simultaneous transition of multiple drug, vaccine, or medical equipment candidates from the technology base into the Concept Exploration phase of 6.3B. In fact, the pre-existence of generic (i.e. CAPSTONE) O&O plans for most vaccines and drugs would make such a practice very simple to implement. The practice of selecting single candidates evolved for many of the same reasons cited for the current Army-wide emphasis on ATTDs and simplified or tailored LCSMMs, as well as for historic reasons relating to the funding structure of medical programs.

The more stringent management procedures that the formal systems acquisition policy (AR 70-1) imposes upon 6.3B efforts are more resource- (and time-) intensive than those required of 6.3A programs. This is a major reason why the Army is shifting its emphasis for proof of principle to ATTDs and other 6.3A technology demonstrations. The hope is that successful ATTDs may allow 6.3B to be skipped altogether, with systems transitioning directly to 6.4 FSD -- further streamlining the transition of new technology into fielded systems.

The necessity of integrating the Army's Systems Acquisition Process and the FDA regulatory process has led to a tailored LCSMM for medical materiel which does not allow "skipping" of 6.3B upon successful demonstration of prototype technology drugs and vaccines in the 6.3A Core drug and vaccine program (i.e., ATTD-equivalent preclinical tests). The FDA process is structured such that no time (or funds) could be saved by transition from 6.3A to 6.4, since the cost of obtaining FDA approval for clinical studies for each of the candidates in 6.3A would be unchanged, and all phases of the clinical tests normally conducted in 6.3B would still need to be completed. These are some of the reasons why medical ATTDs or their equivalent, the Core Drug and Vaccine Program, are different from those of non-medical materiel developers. These differences are further discussed in relation to ATTDs and Next Generation/Future Systems in Section IV.

Although the medical R&D process does not allow for skipping any of the many 6.3B test requirements required for FDA approval of drugs and vaccines, the medical R&D process does allow for speeding new products to the field through a process termed "contingency fielding." Those 6.3B candidates that have been approved by the FDA for human clinical trials and have established their safety in humans can be provided to troops. In essence, the recipients become part of the test population of an

FDA-approved clinical trial for efficacy. Although this process requires adherence to rigid FDA regulations for human use, including obtaining the informed consent of the "test" subjects, contingency fielding does provide the military the potential benefits of drugs and vaccines effective against significant military health threats as early as possible in the development process. In those instances where the military threat does not naturally occur in sufficient cases to establish clinical efficacy -- or has no natural occurrence at all, as in the case of chemical and some biological agents -- the clinical efficacy tests necessary for licensure are not possible and contingency fielding is the only option for military use.

Full-Scale Development (6.4)

The objective of this phase is to prepare a product to enter production and fielding. During FSD, the system (including necessary training devices, threat simulators, test equipment, and computer resources) is engineered, integrated, tested, evaluated, and documented to ensure that it is effective and suitable in its operational environment, meets the user's requirements and is ready for production. FSD also normally provides for limited initial production to verify producibility, ascertain shelf-life of drugs and vaccines and obtain sufficient quantities of materiel for conduct of user/operational tests. The 6.4 activities in drug and vaccine development provide the information necessary for FDA decisions on licensure and commercial production. Examples of medical 6.4 activities are cited in Figure I-8.

- Development of pre-production prototypes for full-scale testing and evaluation
- Producibility studies to ensure large-scale production of final formulation, product, device, or system
- Tests [Technical Test-2 (TT-II)] of pre-production prototypes
- Phase III clinical trials (field trials) to include safety and tolerance, efficacy, side effects, bioavailability, and validation of the final dose, dose form, and regimen
- Follow-on efficacy and validation studies (GLP) of pre-production prototypes in animals when efficacy evaluation in humans is unfeasible or further studies are warranted by the results of clinical studies
- Studies of drug interactions with pre-production prototype
- Preparation of final training and supportability packages
- Preparation and submission of New Drug Application (NDA)/Pre-Market Approval (PMA)/license
- Assessment of on-line production capability of industrial base
- Operational tests with troops and reliability, availability and maintainability (RAM) testing

Figure I-8. Examples of Full-Scale Development (6.4)

SUMMARY

The medical R&D process links the Materiel Developer (USAMRDC) with the Combat and Training Developer [Academy of Health Sciences (AHS)] and the Logistician [U.S. Army Medical Materiel Agency (USAMMA)] in addressing the threat and DoD requirements. For some chemical and all biological requirements, the U.S. Army Chemical School is the Combat Developer and the Army Materiel Command is the Logistician for some of the products the USAMRDC develops. The Army has established a comprehensive approach to the requirements development process, the CBRS, discussed in detail in Section III. Converting these requirements into concepts and solutions provides the USAMRDC with some of its more interesting management challenges. The technical challenges are equally complex, and the neurosciences and biotechnological sciences are among the most rapidly progressing fields in science. The paybacks for an aggressive medical R&D program can be substantial, as discussed in the following sections. Conversely, failure to provide effective medical countermeasures on the battlefield is likely to be a "war-stopper."

Section II

ARMY MEDICAL R&D IN PERSPECTIVE

INTRODUCTION

The numbers of military-unique health threats and approved medical requirements for materiel and information have always exceeded the resources available to address them. In times of budgetary austerity, costs of medical R&D seem great, but payoffs in increased or sustained mission capability and reduced costs for health care delivery far exceed the investment. The challenge for the Army's Medical R&D community is to maximize the return on the investment; the challenge for the Army leadership is to recognize that the payoffs make medical R&D one of the most cost-effective choices available in an era of constrained resources. This section provides the perspective which validates these points.

The medical materiel and information products realized as a result of Army medical research and development have resulted in both actual and potential cost savings as well as increased combat and mission effectiveness. Personnel are the Army's most expensive and vulnerable weapon system and medical materiel and information keep soldiers at their missions. Cost savings have been obtained in three distinct areas: (1) mobilization, deployment, and operational costs; (2) reduced training, hospitalization, and manpower costs; and (3) reduced morbidity and mortality. Although there are many examples of direct savings, the most significant payback from Army medical R&D is its impact on mission effectiveness. Increased combat effectiveness and mission effectiveness result from reduced casualties, more rapid return of wounded to duty, and reduced performance degradation. Furthermore, products of medical R&D contribute significantly to improvements in doctrine and training, which are reflected in increased fighting effectiveness and improved soldier sustainment.

This section presents a perspective of the Army medical R&D program and its achievements throughout more than 200 years of history. These accomplishments demonstrate the importance and the validity of continued investment in Army medical R&D. The unique character of military medical R&D programs is contrasted with civilian programs. A discussion of the impact (both actual and projected) that medical R&D has on the Army's warfighting mission follows these accounts and provides the historical and prospective bases for recognizing the return on investment.

HISTORY AND MILESTONES OF ARMY MEDICAL R&D

Historical Perspective

Biomedical research programs are the oldest research programs in the Armed Forces. From the first command-directed immunization program -- inoculation for smallpox in Washington's Army -- through the initiation of health and weather reporting in 1818, Beaumont's studies of digestion beginning in 1824, the founding of the first American School of Preventive Medicine and Public Health in 1893, Reed's 1900 proof that mosquitos transmit yellow fever, and up to and including the present time, many military and civilian medical scientists continue to make seminal contributions to military and general medicine.

Army medical research has played an important role in national defense throughout history by continually responding to emerging threats. The medical achievements of the Army for more than 200 years have benefited people throughout the world. Table II-1 lists some of these accomplishments chronologically for both medical materiel and medical information. The research programs of the USAMRDC have made contributions to this record of achievement, along with military and civilian medical scientists and various military medical programs of the past.

Table II-1. The History and Major Accomplishments of Military Medicine

Medical Materiel	*Medical Information*
	1775 - The 1st American textbook on surgery, Plain, Concise, Practical Remarks on the Treatment of Wound and Fractures, was published.
	1777 - GEN Washington ordered the variolation of the Continental Army to prevent smallpox. 1st time an entire army was immunized for a contagious disease.
1779 - The 1st effort to construct isolation wards to guard against cross infection.	1778 - The 1st Pharmacopoeia to be printed in America was compiled by Army surgeons at Valley Forge and known as the "Lititz Pharmacopoeia."
1812 - War Dept. ordered that vaccination be substituted for inoculation to prevent smallpox. Milestone in military preventive medicine.	- Directions for Preserving the Health of Soldiers: Recommended to the Consideration of the Officers of the Army of the United States was the first textbook on preventive medicine published in this country.
	1818 - Meteorological records were kept to investigate the relation of disease incidence to climate and weather.
	1819 - TSG ordered the collection of records of the sickness and mortality of troops to collate data and make comparisons among geographical areas. These reports became the 1st American health statistics, published in 1840.
1833 - Surgeon W. Beaumont published Observations on the Gastric Juices and Physiology of Digestion based on a 10-year study of an accidental stomach fistula. Study became cornerstone of modern gastroenterology.	
	1862 - Establishment of the Army Medical Museum for collecting and preserving specimens illustrative of wounds and diseases causing death and disability in the Army.
	1863 - TSG W.A. Hammond wrote and published A Treatise on Hygiene with Special Reference to the Military Service.
	1864 - The 1st clinical definition of causalgia and nerve regeneration was published in Gunshot Wounds and Other Injuries of Nerves.
1892 - MAJ G.M. Steinberg introduced the virus neutralization test.	1892 - Studies regarding wound ballistics proved that wounds
1893 - The Army Medical School, the oldest school of preventive medicine and public health in the U.S. (now the Walter Reed Army Institute of Research) was established.	to 1914 from bullets were not sterile and in contrast to the accepted view that the heat of the bullet destroyed the micro-organisms on skin and clothing, they were actually conveyed directly into the wound.
	1898 - The Reed-Vaughan-Shakespeare Typhoid Board found that typhoid fever was spread mainly by contact between persons and documented that the control of sanitation was the responsibility of the line commander.
	1899 - It was discovered that Puerto Rican anemia was caused by a New World type hookworm, *Necator americanus*. A drug therapy and a prevention and control program were developed that reduced an endemic disease to a sporadic occurrence.
	1900 - Walter Reed proved that yellow fever was transmitted by *Aedes* mosquitos.
	1904 - COL W.C. Gorgas' work as a sanitarian in Panama resulted in the control of malaria in the Zone as well as marked reduction in tuberculosis and other diseases and enabled the building of the Panama Canal.
1909 - MAJ F.F. Russell developed an effective antityphoid	
to 11 vaccine. Immunization against typhoid fever was made compulsory for the Army and Navy in 1911. Typhoid fever, a major cause of manpower loss in all previous wars, was eliminated.	1911 - CPT Vedder demonstrated the specific use of emetine in treating amoebic dysentery.
	1913 - Good hygiene, emphasized to prevent tuberculosis, brought about new attitudes and practices about this disease.

Table II-1. The History and Major Accomplishments of Military Medicine (continued)

Medical Materiel	*Medical Information*
	1914 to 18 - The greatest triumph of WW I from a medical point of view was the direct application of the science of infectious diseases to military sanitation. This was the 1st war of magnitude in history in which the mortality from communicable diseases was less than that from battle wounds.
1918 - A simplified test for the detection of syphilis was devised and used as the primary standard serological test for a number of years.	1918 - A therapeutic system for treating patients with "shell shock" was developed; manpower losses and long-term disability were reduced.
	1923 - The closed method for treating compound fractures was developed.
	1925 - The Medical Aspects of Chemical Warfare was published based on research during and after WW I. Included full discussion of the means of both individual and collective protection against chemical warfare agents.
1927 to 33 - The rinderpest vaccine and a new chloroform-treated rabies vaccine were developed.	
1929 - 1LT C.F. Craig demonstrated that amoebae produced antibodies in the serum of humans, and developed the 1st serological test (complement-fixation) for amoebiasis.	
1933 - Atabrine (quinacrine; mepacrine) was tested as a substitute for quinine in combating malaria.	
	1935 - Studies on effects of high velocity missiles documented the fact that they create a transient, negative pressure cavity in passage and cause deformation and injury beyond the obvious.
1939 to 49 - Mass production techniques developed for growing the viruses of Western and Eastern equine encephalitis in eggs, enabled the large scale production of killed virus vaccines for these diseases.	
1940 to 45 - Studies of whole blood preservation brought about the development of lots for sterile collection of blood from donors and for rapid typing of blood, the 1st system for mass collection and shipment of liquid and dried plasma, the use of human albumin to treat shock, and contributions to the development of the system for collecting and refrigerating whole blood and shipping it overseas.	1941 to 43 - The biological warfare threat was identified.
1942 - The discovery of a specific soluble polysaccharide antigen from rickettsial cultures restored the potency to the vaccine that prevented epidemic typhus.	1942 - Foundations were laid for the present scientific capability to design protective clothing and individual equipment, to define water requirements in the heat, to describe the processes of acclimatization and physical conditioning, and to relate physical anthropometry to human engineering of vehicles.
1943 - DDT was given its 1st major field test in Naples, where it stopped an epidemic of typhus. Army malaria control teams introduced the use of DDT for mosquito control in the Pacific in 1944.	1943 - The Medical Section of the Manhattan Engineering District was created to define health hazards involved in this project, which eventually produced the atomic bomb. The section devised and supervised safety procedures, conducted research in radiation biology, and was responsible for the care of the populations where research was being conducted.
	1944 to 45 - Studies of shock and the resuscitative process showed the need for using whole blood rather than plasma and made clear that many hypotheses about shock were in error.
1945 - The 1st American center for the study of patients with burns was established and called the *U.S. Army Surgical Research Unit*. The unit (now USAISR) was the prototype for the many "burn centers" now established throughout the country.	1945 - TSG added "transient personality reactions to acute stress" to list of standard diagnoses, incorporated WW II experience with combat fatigue, similar nomenclature subsequently adopted by AMA and VA.

Table II-1. The History and Major Accomplishments of Military Medicine (continued)

Medical Materiel	*Medical Information*
	1949 - The 1st specific cure of typhoid fever with chloramphenicol was reported.
1951 - The first U.S. Army helicopter detachments with the primary mission of casualty evacuation became operational in Korea. Tests of forward air ambulances led to the development of the UH-1 "Huey" helicopter, which was widely used as an ambulance and troop carrier in Vietnam.	1951 - Studies in Madagascar demonstrated that broad spectrum antibodies would cure septicemic and pneumonic types of human plague.
	1951 to 53 - Newer methods taught in Korea on repair of vascular injury markedly reduced the amputation rate. Advanced methods of resuscitation from shock were employed and the first artificial kidney ever brought to a combat zone was used.
1955 - The soft ear insert was developed for defeating noise, which was a major improvement over the hard acrylic ear insert for comfort, safety, and acoustical seal.	
1955 to 60 - A gastrointestinal biopsy capsule was developed that permitted *in vivo* biopsy of any portion of the human gut.	
- The concept of "jet injection" was introduced for immunization, and the jet injector "gun" developed for mass immunization of troops eliminated the need for needles and syringes.	
1956 - The U.S. Army Medical Unit was established at Fort Detrick and studies were initiated in research and development in defensive biological warfare.	
1958 - The USAMRDC was established.	1958 - The first edition of Emergency War Surgery, the U.S. version of the NATO Emergency War Surgery Handbook, was published.
	- The Wind Chill Chart was published based on research conducted in the Antarctic in 1948.
1960 - A safe, living, attenuated vaccine for Venezuelan Equine Encephalitis (VEE) was developed.	1960 to 70 - Studies on the ecology of plague in tropical areas related plague epidemics to weather as a function of flea physiology. Serological tests were developed for plague infection.
- A malaria chemoprophylactic for *vivax* malaria that would both suppress clinical attacks and prevent relapses was provided in the "once-a-week" combination tablet of chloroquine diphosphate and primaquine.	
1961 - The USARIEM was established.	
1962 - The USAARL and the USAIDR were established.	
1962 to 69 - The rubella virus (German measles) was isolated from the blood of a recruit hospitalized at Fort Dix. The vaccine produced by the NIH in 1969 was derived from this virus strain by virological techniques developed at the WRAIR.	1963 - The causative virus of hemorrhagic fever was isolated by a research team in South America.
	1964 - Clinical studies of the pathophysiology of infectious hepatitis demonstrated the multiorgan, multisystem effects of this disease, and possibly many other viral infections.
1965 - Sulfamylon, an antibacterial cream, was developed for the treatment of patients with extensive burns.	1965 - A Vascular Surgery Registry was established at the WRAMC to follow up patients with vascular injuries from the Korean and Vietnam Wars.
1966 - The 45th Surgical Hospital, the 1st medical unit, self-contained, transportable (MUST) hospital in Vietnam, became operational.	1966 to 69 - Studies involving the infection of owl monkeys with *vivax* malaria and *falciparum* malaria determined the responses of infected monkeys to various new antimalarial drugs. These studies made available for the 1st time a feasible experimental model for testing new drugs against those strains of malaria that infect man and enabled researchers to begin extensive *in vitro* lab studies not previously possible because of the lack of a continuous supply of fresh parasites.

Table II-1. The History and Major Accomplishments of Military Medicine (continued)

Medical Materiel	*Medical Information*
1967 to 69 - A live oral vaccine against adenovirus type 7 was developed, in combination with the previous vaccine for type 4, markedly reducing the incidence of upper respiratory infection in recruits in training.	1967 to 71 - Research was conducted on the value of U.S.-produced gamma globulin in preventing hepatitis in U.S. soldiers in Korea. Results showed that it provided significant protection against clinical hepatitis Types A and B in overseas areas; delineated the effective dose, the period of protection, and the groups at greatest risk; and showed that those who still developed hepatitis had a milder disease.
1967 - Development of adenine, used to prolong survival of red blood cells.	
1969 - The U.S. Army Medical Unit at Ft. Detrick was redesignated the *U.S. Army Medical Research Institute of Infectious Diseases.*	1969 - COL F. La Piana, WRAMC ophthalmologist, tested a wrap around configured, polycarbonate injection-molded form of eye protection in Vietnam that involved the ultimate user in the early development stages.
- The USAISR was established.	
- The LAIR was established from the U.S. Army Medical Unit, Presidio of San Francisco.	
- A pulse-pressure technique for water lavage (jet lavage) by modification of the dental "water pick" was developed. The pulsating technique, coupled with novel applicator tips, became a new technique for surgical debridement.	
- Daily use of Griseofulvin tablets by the Army reduced the incidence of fungus skin disease.	
1969 to 70 - The VEE vaccine was used in Central America to control an epidemic.	
1970 - A polysaccharide vaccine against Group C meningococcus, which prevents meningococcal disease and thus prevents the epidemic spread of meningitis in recruit camps, was developed.	
- Development of pulse pressure lavage for pre-surgical scrub.	
1970 to 72 - The VEE vaccine was used to halt epizootic spreading from Mexico into Texas.	
1971 - The 1st mass screening laboratory for urinalysis for heroin in large populations was established. This program began in Vietnam and expanded to include amphetamines and barbiturates.	
1972 - The USAMRDL was established.	
	1973 - A Rare Donor Register was established at Fort Knox, KY.
1979 - A blood preservative, Citrate Phosphate Dextrose Adenosine-1 (CPDA-1), was improved.	1979 - Improvements were made in the early diagnosis of burn wound infection and in the diagnosis of inhalation injury.
- The Biomedical Lab was transferred to the USAMRDC and became the USAMRICD in 1981.	- Large scale studies of "jet lag" in conjunction with REFORGER exercises in Germany resulted in an SOP for rapid deployment forces.
	1980 - Surgical excision techniques for burn treatment were improved.
	- Thyroid hormonal deficiency was demonstrated to occur after a burn injury.
	- Computer model of wound was confirmed in tissue simulants.
	- Preliminary pollutant limit values were developed
	- Heat injury guidelines were established.
1982 - Improvements were made in a field surgical light for the operating room.	1982 - Developed and implemented a Military Entrance Physical Strength Capability Test (MEPSCAT) for evaluating and qualifying new accessions for Military Occupational Specialty (MOS) assignment.

Table II-1. The History and Major Accomplishments of Military Medicine (continued)

Medical Materiel	*Medical Information*
1983 - Nerve agent antidote kit fielded.	1983 - Zinc supplementation was found to reduce infections of burn injuries. - M198 hearing protection limits were established.
1984 - The USAMRAA was established.	
1985 - The USAMMDA was established. - Heat Strain Calculator demonstrated. - Computer Aided Post Mortem Identification (CAPMI) system -- used for the first time in a military mass casualty situation (air crash, Gander, Newfoundland) to identify deceased soldiers.	1985 - Improvements were made in the diagnosis of severe blast injury to the gastrointestinal system.
1986 - Developed an improved case for the surgical instrument and supply set (Medical Aidman's "bag"). - A mobile biomonitoring trailer was developed. - Repackaged cyanide antidote fielded.	1986 - Monoclonal antibodies were shown effective in treatment of two common types of facial wound infections. - Ammo plant water quality criteria were developed. - AIDS diagnostic and staging schemes were published and adopted by the DoD, many State health departments, and foreign health departments. - Applied and implemented the 40-and-over Cardiovascular Screen to identify personnel at risk for heart disease prior to participating in physical training.
1987 - A post-thaw preservative for frozen blood was developed. - Development of ballistic-laser protective spectacles was completed. - Nerve agent pretreatment (pyridostigmine) fielded.	1987 - Treatment for adult respiratory distress syndrome was improved. - Development of improved surgical treatment of gunshot wounds. - Microwave exposure effects and laser glare effects were demonstrated. - Results of psychological sequelae studies at Fort Campbell after the Gander air disaster were incorporated into Chaplain training throughout the Army.
1988 - Development completed of: • field x-ray/fluoroscopy unit • wheeled litter carrier • field medical refrigerator • decontaminable folding litter • arthropod repellent • CWA protective patient wrap • dental miniaturized field x-ray - Fielded charcoal heater unit for management of cold casualties.	1988 - AIDS testing was implemented Service-wide and established standards for other testing programs (high accuracy and low cost). - Contribution of several chapters to the Emergency War Surgery NATO Handbook. - A new body fat prediction equation was devised. - Demonstrated in primates the value of anticonvulsant therapy for soman intoxification. - Target acquisition prediction studies were completed. - Updated 1978 TB MED 81 on cold injury. - Published text book, Human Performance and Environmental Medicine at Terrestrial Extremes. - Prepared NATO Handbook, Biomedical Effects of Military Clothing and Equipment Systems.
	1989 - Human performance assessment methodology validated. - Published FM8 285, Treatment of Chemical Agent Casualties and Conventional Military Chemical Injuries. - Published AMedP-6, NATO Handbook on the Medical Aspects of NBC Defensive Operations. - 15 medical specialists and 7 tons of medical supplies and equipment were deployed within 24 hours to the Soviet Union to support burn injuries resulting from the disastrous explosion and train wreck in the Urals.

Historical Relationship Between Military and Civilian Medical R&D Programs

Medical R&D is conducted within three domains: the military, the Federal Government, and the private sector. The Federal focal point for health research is the National Institutes of Health (NIH), an agency under the Department of Health and Human Services. The NIH had its origins in the establishment of a bacteriological laboratory in 1887 under the Marine Hospital Service in Staten Island, New York. Renamed *The Hygienic Laboratory* in 1891, it was moved to Washington, DC, later to be redesignated the *National Institutes of Health* by Congress.

In 1902, Congress changed the name of the Marine Hospital Service to the *Public Health and Marine Hospital Service*. In 1912, the name of the Public Health and Marine Hospital Service was changed to *Public Health Service* (PHS). In 1922, the Library of the Office of the Surgeon General (Army), which was established in 1836, was renamed the *Army Medical Library*; in 1952 it was renamed the *Armed Forces Medical Library*, and finally in 1956, it was transferred to the National Institutes of Health as the *National Library of Medicine*.

During World War II (WW II), military-sponsored medical research had a clearly defined objective: to come up with immediately applicable results. After the war, the Office of Scientific Research and Development transferred its existing medical research efforts to the Public Health Service; the PHS Surgeon General and the Director of NIH directed these efforts toward a large-scale, peacetime program of long-term support to scientific research in medicine through extramural research grants and fellowship awards. By the end of 1946, the program was a reality.

In 1943, the Army Surgeon General's Medical Research and Development Board was established to coordinate all medical department research with other components of the Army as well as with agencies outside the Army. In 1958, the Army Medical Research Board was converted to the U.S. Army Medical Research and Development Command, the central agency for all Army military medical research and development to improve preventive medicine measures and rapid treatment techniques. The research programs of the USAMRDC address military-unique medical problems and apply directly to preserving the health and safety of soldiers. The USAMRDC mission is summed up in its motto – " Research for the Soldier."

A superficial examination of the mission statements of the USAMRDC and the NIH gives rise to the mistaken perception that there are many areas of apparent overlap in program goals and content. Critics of the Army's continuing investment in medical R&D have pointed to the large investment in these areas within the private sector. The military has frequently been challenged to explain the apparent similarities of its medical R&D program to national biomedical research programs. Although there are areas where such overlap appears to occur, the similarities in military and civilian programs rapidly disappear under close examination. Section V summarizes some of the more important differences (see Figure V-9).

Vaccine and drug development is a long and arduous process requiring stable, long-range fiscal and manpower commitments and the investment strategies of military and nonmilitary R&D differ. For example, U.S. industry does not consider the development of drugs and vaccines against most of these militarily significant diseases commercially viable. Drug and vaccine development depends on sequential steps beginning with identification and characterization of the threat agent and culminating in safety and efficacy testing of the biological or pharmaceutical countermeasures in both animals and humans. Many of these steps must meet regulatory requirements, including those established by the FDA. The Army is fortunate to have one of the world's most successful drug and vaccine developers, the USAMRDC, at work on the required countermeasures. For a detailed comparison of military and industrial research and development investment strategies, see Annex A.

IMPACT OF THREATS ON WARFIGHTING MISSION

The most important warfighting system of the Army is the individual soldier -- well trained, well-equipped, in top physical and mental condition, and in sufficient numbers. Threats to the health and performance of this system are the focus of military medical R&D. These threats exert their impacts on the Army in war and peace, from accession and mobilization through training, to deployment and sustainment in combat.

Military health threats can be divided into three broad categories which are synonymous with the traditional categories of casualties -- disease, training and nonbattle injuries, and battle injuries. *Disease* is defined as a specific morbid condition resulting in sickness or illness; *training and nonbattle injuries* include a traumatism or injury resulting from conditions other than a direct, or indirect, secondary result of a hostile act of a military enemy, or musculoskeletal injuries incurred in a training environment; and *battle injury* is a term used to record the wounded -- it is associated with diagnostic groups of traumatisms that are incurred as a direct or indirect, secondary result of a hostile act of a military enemy.

Disease

The graphic images of wounded soldiers -- their blood and agony, which have always been intimately familiar to combatants and are now firmly and vividly in the minds of the noncombatant population as well in this age of electronic news gathering -- lead many to assume that the primary focus of military medical R&D is to address the threat of battle injury. Although combat casualty care is an important and all too necessary concern of military medical R&D, it is not the primary concern, nor do combat injuries constitute the most significant medical threat to the success of military operations. As MAJ W. S. King, U.S. Army Surgeon and Medical Director, commented after the first battle of Bull Run, "Diseases destroy more soldiers than do powder and the sword" (Woodward and Otis, 1870).

Disease is the major cause of lost man-days in all wars. An ailing man does not fight well -- a sick man cannot fight. In WW II, the Army lost 286 million man-days to disease; or, the equivalent of 11 divisions every year were not available for combat. Two-thirds of all U.S. casualties in Vietnam were due to infectious disease, in 1968 infectious disease alone resulted in more than 750 thousand man-days lost from duty in Vietnam or the equivalent of nearly one combat brigade for a year. In the continental United States (CONUS) and noncombat overseas areas, nearly 2 million man-days in 1968 were lost because of infectious disease. Figure II-1 depicts the percentages of disease, nonbattle injury, and battle injury hospital admissions for WW II, Korea, and Vietnam.

The impact of infectious disease on military manpower is enormous; every element of our forces is affected. Epidemics, such as influenza, can totally incapacitate operational units. Military forces are at risk in both peace and wartime.

Deployed combat forces are in double jeopardy from epidemic diseases; they have no natural immunity to tropical and exotic diseases and are at high risk of exposure because of decreased control of sanitation and the environment. The principal threat agents are enteric and vector-borne diseases, which because of rapid transmissibility and short incubation periods, have high epidemic potential and can render a deployed force ineffective within days or weeks. Specifically, the current threat presented by dysentery, malaria, and certain viruses (including dengue, Chikungunya and Rift Valley Fever) is every bit as severe as the threat presented by typhus, plague, and cholera to past armies. Malaria and dengue in particular are very serious worldwide civilian problems and are increasing in magnitude and distribution. For example, dengue is presently a serious epidemic illness in Central America. Thus the threat to the military is greater now than at any time in history. In planning for present and future military operations, the Army Medical Department (AMEDD) must assess the probable impact of disease on military forces and plan to use whatever countermeasures are or are projected to be available to lessen the impact of this formidable threat.

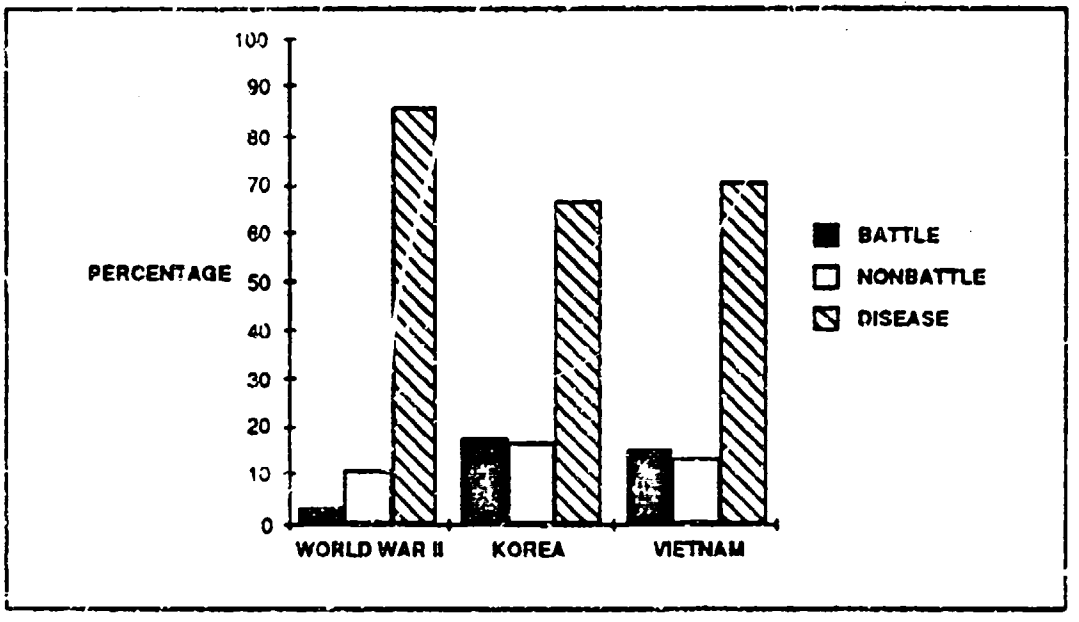


Figure II-1. Causes of Hospital Admissions in WW II, Korea, and Vietnam

The platforms from which diseases are launched -- food, water, mosquitoes, mites -- are innocuous. Loss of control over the environment that harbors disease places the effectiveness of rapidly deployed forces at high risk of incurring substantial rates of noneffectiveness. Normal preventive medicine measures, which keep disease risk relatively low in peacetime, are lost in times of disruption and conflict, with a resulting rise in disease incidence in both native and foreign populations.

Later, and only slightly less serious, threats to deployed forces are diseases that can seriously deplete forces over a period of weeks or months. Diseases such as schistosomiasis and loishmaniasis are present in South America, Africa, and Asia and are serious epidemic problems in the Middle East. These diseases have longer incubation periods but are characterized by high attack rates in exposed personnel and result in significant performance degradation and noneffectiveness. African trypanosomiasis, endemic in regions of sub-Saharan Africa, is a similar but geographically limited problem. Several viral diseases such as viral encephalitis and viral hemorrhagic fevers also may have significant impact on deployed forces, including a severe impact on morale. Mobile operations usually preclude effective vector control measures and increase the risk of exposure. Exposure to water-borne schistosomiasis and leptospirosis may be an operational necessity and, as in the past, may result in many casualties.

Naturally occuring infectious and parasitic diseases alone may account for significant military casualties, but they pose an added threat to the soldier whose immune system has been depressed or who displays increased susceptibility as a result of other battlefield stresses -- such as radiation, lack of sleep, dehydration, temperature extremes, possibly toxic smokes and chemicals, and psychological stresses of the high intensity battlefield. Knowledge of the additive or synergistic effects of combined stresses on military effectiveness is minimal. Individuals who survive the potentially lethal effects of the modern battlefield may succumb to the more primitive but equally effective threat of disease. Table II-2 presents examples of the impact selected diseases have had on units.

Table II-2. Operational Impact of Selected Diseases

Disease Threat	Setting	Operational Impact
Smallpox	Revolutionary War, 1775-1777	Major factor in the failure of the Quebec Campaign and in the great suffering and mortality among troops
Tuberculosis	1913	Major cause of morbidity and mortality in troops
Influenza	1917 - WW I	More than 30% of all Army personnel infected and killed 1 of every 100 enlisted men
Influenza A	1972 - Air Force Base in Thailand	More than 60% of Air Force pilots incapacitated in 1 week, combat operations significantly [illegible]ndered
Malaria	WW I - Macedonian Campaign	80% of French troops hospitalized; 160,[illegible]00 British casualties
	WW II - Guadalcanal	100,000 casualties in 8 months -- 5 times as many as from battle injuries
	Vietnam	Well over 1,000,000 man-days lost; more than 80,000 casualties in spite of preventive measures; evacuations for malaria often equaled those for wounds.
	Vietnam - Ia Drang Valley	Casualty rate of 60%; 2 battalions ineffective
Dengue	WW II - New Caledonia April 1943	645 cases/1,000 troops/annum
	WW II, 1942-1945	90,000 recorded cases; casualty rate peaked at 1%/day in Saipan
	Airfield at Hang Kow, China, immediately after V-J Day	40 of the first 46 military personnel deployed developed dengue fever within 10 days
Schistosomiasis	1944 Invasion of Leyte	1700 cases; attack rates for engineers exposed to water while constructing bridges = 71-82%
Rickettsia - Scrub Typhus	WW II - Sansapor, New Guinea 1st Infantry Regiment	~93% disease casualties among 6,000 men in 53 days
Leishmaniasis	WW II - Persian Gulf Command	Attacked 5% of troops during 3 peak months
	Panama - jungle warfare training	More than 300 cases since 1958
Hemorrhagic Fever	Korea, 1951-1954	2,500 cases with 5% fatalities; special Army hospital established for treatment
Enteric Disease	Operation Bright Star '83 82nd Airborne Division Cairo, Egypt	Diarrhea in over 30% of a 500-man contingent
	Lebanon, 1958	50% of Task Force 201 had diarrhea during 1st month of deployment
Japanese Encephalitis	Vietnam	~200 cases/year

Infectious disease causes a huge loss of manpower outside the combat zone as well. In 1968, nearly two million man-days were lost in the CONUS and non-combat overseas areas. Mobilization of forces carries an increased threat to unseasoned recruits of contracting debilitating diseases such as respiratory infections, hepatitis, and viral meningitis, with a concomitant decrease in readiness. These diseases have no geographic boundaries but occur in specific environments where troops are housed in close conditions. They place a heavy burden on medical support facilities, as high percentages of infected personnel require prolonged hospitalization.

Acute respiratory disease (ARD) such as epidemics of adenovirus respiratory infections in Army base camps and training posts caused 65,000 hospital admissions in the 1968-1969 respiratory disease season in the United States. Moreover, during the 1960s, nearly 50 percent of basic trainees on Northern posts required hospitalization for acute respiratory disease during the 8 weeks of basic training. This represented hospitalization rates of 6-8/1000 men/week and caused substantial difficulty in terms of disrupted training schedules and overtaxed medical resources. The development of effective adenovirus (types 4, 7, 21) vaccines by the Army has virtually eliminated ARD as a military problem.

Military recruits in basic training had a tenfold higher than normal risk of contracting meningococcal disease (meningitis). Of the 200-300 cases a year throughout the 1960s, 7-10 percent died, and the remainder were hospitalized for 3-6 weeks. Great as these costs were in lives and dollars, more critical to military posture was the interruption of training by forced closing of training centers in order to control meningitis outbreaks. A polyvalent vaccine developed by the Army has eliminated all but group B meningitis as a military threat.

The incidence of sexually transmitted diseases (STDs) is highest among young adults between the ages of 18 and 30 years, the bulk of the military population. These diseases (e.g., gonorrhea, syphilis) have presented deployment and sustainment problems throughout history. As recently as the Vietnam war, more than 10 percent of Army personnel were treated for STDs annually. In high risk areas of the world, the infection rates have recently exceeded 100 percent (with repeat cases). The growing incidence of antibiotic-resistant strains of these diseases increases their threat to the operational readiness of the Army.

An STD with even more serious implications for the Army results from infection with the Human Immunodeficiency Virus (HIV); the late disease stage of this infection is known as Acquired Immune Deficiency Syndrome (AIDS). The scope of the problem is shown in Figure II-2. Screening recruits for the HIV infection reduces but does not eliminate the problem. Annual repeat screenings of active duty personnel indicate 600 new cases of HIV infections in previously healthy soldiers. The Army Science Board's study of the AIDS problem estimated the total cost of this disease at $250 K per individual (e.g., medical care, benefits, training of replacements). Figure II-2d shows two possible growth paths for the annual HIV costs to the Army. The lower estimation is based on no increase in the rate of infection, while the higher estimation is based on an incidence increase of 20 percent per year. Hidden health care costs also include dependent care. Of the first 1,609 HIV-positive, active duty Army members, 40 percent were married, the rate of infection of their children approached 25 percent.

The Army Medical Department does not yet have in its inventory the necessary countermeasures to provide adequate protection against many disease threats. Specifically, prophylactic countermeasures against malaria, dengue, dysentery and most other militarily significant diseases are either non-existent or seriously deficient. These disease threats and the worldwide distribution of diseases are more clearly defined in Annex B.

The proven historical deleterious impact of naturally occurring disease and the existence of diseases in contingency areas as established by the intelligence community make it imperative that military forces have effective vaccines and drugs readily available to counter the threat of infectious and parasitic disease. Preservation of available manpower is absolutely essential to a rapidly deployed force with a long

logistical tail and minimal medical support. Development, production, and strategic stockpiling of these countermeasures are critical to assure U.S. forces of the readiness to rapidly mobilize, deploy, and perform their missions in any geographic region. Disease threat must be considered part of the equation on the integrated battlefield; man is the vulnerable component.

HIV ADVERSELY IMPACTS THE COMPLETE SPECTRUM OF MILITARY ACTIVITIES

GENERAL CONSIDERATIONS	PEACE TIME	WARFIGHTING CONSIDERATIONS
WORLDWIDE DISTRIBUTION	STATIONED FORWARD (DEPLOYMENT) IN ENDEMIC AREAS	FIELD BLOOD SUPPLY
HIV IS A SEXUALLY TRANSMITTED DISEASE		MOBILIZATION
HIV CONTAMINATES BLOOD		MEDICAL SUPPORT MILITARY (BUDDY CARE) CIVILIAN
DEPLOYMENT TO HIGH INCIDENCE AREAS		HEALTH THREAT TO FORCE PERFORMANCE DECREMENTS UNIT MORALE AND COHESION INTERACTION OF LOCAL POPULATION CAN ADVERSELY IMPACT SUCCESS
DESTABILIZATION OF GOVERNMENTS	HEALTH CARE COSTS	

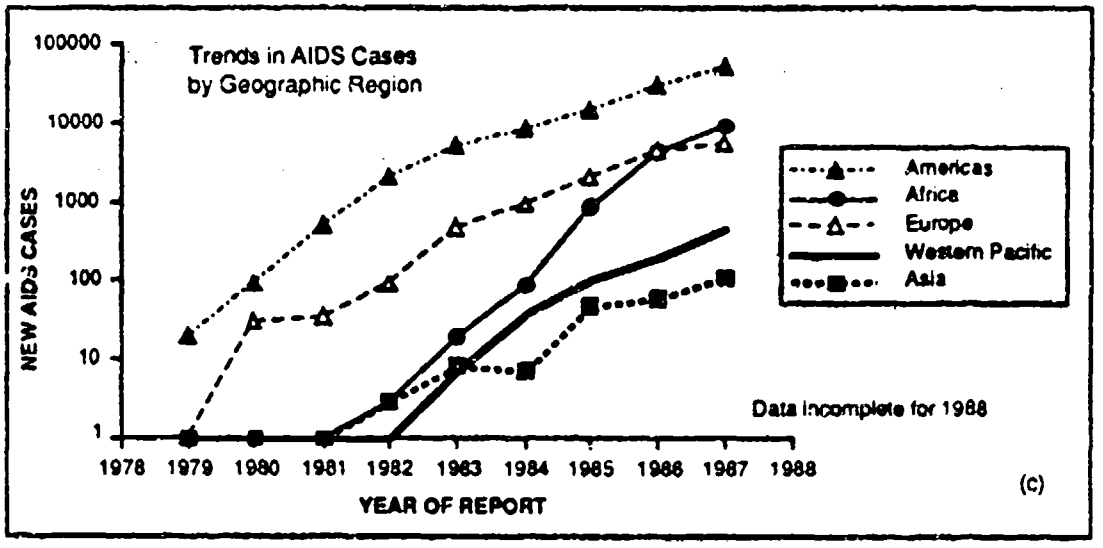
(a)

FUTURE IMPACT OF AIDS ON MILITARY-AGED MANPOWER POOL (18-26)

	AIDS (WR STAGE 6)		
	NEW CASES	TOTAL CASES	HIV INFECTION
1980	25		
1983	3,500	3,500	35,000 - 87,500
1985	11,500	15,000	150,000 - 375,000
1986	15,000	30,000	300,000 - 750,000
1987	20,000	50,000	500,000 - 1.25 M
1989	33,000	83,000	830,000 - 2.08 M
1992	50-60,000 65-90,000	160-180,000 (CDC) 200-240,000 (GAO)	1.6 M - 4 M 2 M - 6 M

(b)

Figure II-2. The Scope of the AIDS Problem



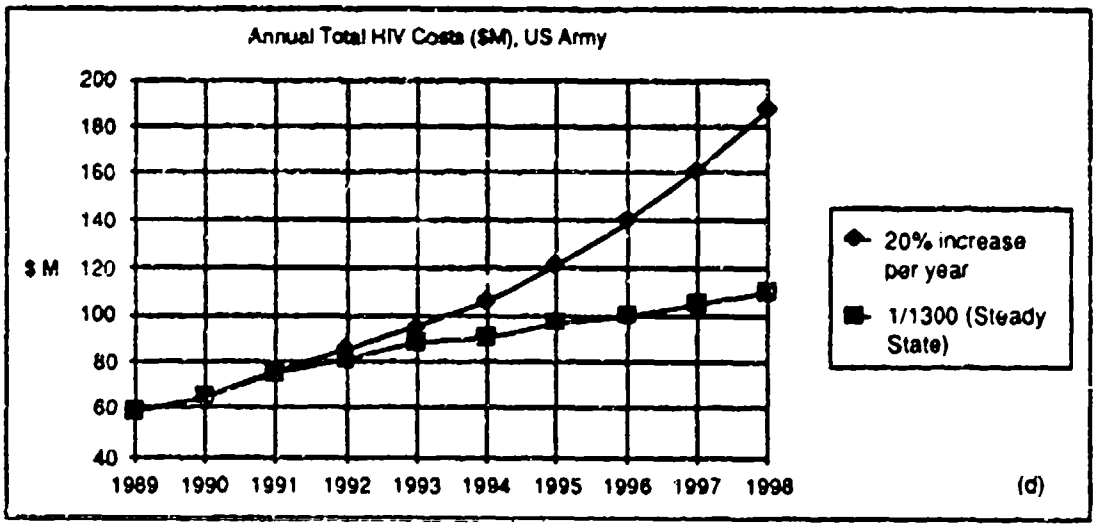


Figure II-2. The Scope of the AIDS Problem (continued)

Training and Nonbattle Injury

While soldiers are faced with a wide variety of battle injuries and diseases, also important are the nonbattle injuries that troops succumb to in both the training and combat scenarios. The occupational environment of the fighting man is often markedly different from that of civilian life. The historical hazards linked to battle injury -- the missiles, flame, and projectiles of the enemy -- are only some of the unique threats of injury faced by military personnel. Climate and terrain also pose significant threats to health and operational capability; desert heat, arctic cold, and high altitude have always caused significant casualties. Weapons systems based on new technologies and materials expose men to hazards of toxic fumes, carcinogens, and electromagnetic radiation from their own weapons systems.

The capabilities and limitations of the human operator are critical considerations in the design and function of modern weapons systems. Human sensory, perceptual, and cognitive abilities are major components of systems for command, control, pattern recognition, decision making, and information processing. Failure to take into account the limitations of human performance during systems design can lead to increased injuries during operation. Biomedical disciplines such as sensory physiology, nutrition, and the psychophysiology of stress have made significant contributions to maximizing safety of operation and human performance.

With its orientation to the interactions among the physiological, emotional, and behavioral aspects of human effectiveness, psychiatric research provides a base of knowledge applicable to many problems of health, safety, and human performance in military operations, systems and populations. Deprivation of sleep and severe stress and psychiatric disorders resulting from intensive combat present severe health and performance challenges to the fighting soldier. For example, neuropsychiatric illness has historically been a major source of manpower loss and related costs to the military services. During World War I (WW I), over 97,000 men were admitted to hospitals; in WW II, there were more than 1,000,000 hospital admissions for neuropsychiatric reasons.

For most of the hazards described, totally effective treatment does not yet exist. The present and near future work is aimed mainly at describing effects and determining human tolerance so as to set safety limits and prevent injuries and performance decrements. Not only are effects and responses defined in biological terms, but any adverse changes in military job performance -- e.g., in hot climates -- should be quantified for the use of operational planners and military staff officers who estimate strategic and tactical deployment of units.

Preparing for war requires that soldiers train and work in environments that they are likely to encounter under actual combat conditions. Physical training exposes soldiers to musculoskeletal injuries; training and fighting in radical environments expose soldiers to numerous opportunities to fall prey to injuries from cold, heat, altitude and other extremes. Throughout the history of modern warfare, threats from the soldier's environment, specifically climatic extremes and traditional non-battle injuries, have often been the leading causes of death and mortality. Although there are many potential nonbattle threats, a brief discussion of several of the more pervasive nonbattle hazards will illustrate just how seriously these hazards can impact readiness and soldier effectiveness.

Cold. Non-freezing cold injury ("trenchfoot") has long been a consequence of military operations in a cold, wet environment. The term "trenchfoot" was coined in WW I where hundreds of thousands of troops were affected due to long periods of trench warfare. In WW II there were over 90,000 cases of "trenchfoot" in U.S. soldiers and approximately 1 percent of the cold injuries reported in Korea were of the cold-wet type. Cold injury was one of the most frequent causes of hospital admission in winter fighting in WW II. Occasionally, as in the Aleutian Campaign, casualties caused by cold injury were equivalent numerically to the wounded in action. Cold injury was almost totally confined to front line soldiers and, in a cold and wet environment, it increased in proportion to the demands of combat. Unlike minor missile wounds, which healed rapidly, cold injury of even a moderate degree rendered well-trained and experienced soldiers unfit for further duty for long periods of time, some even permanently. Cold injury has long been recorded as a serious problem in winter fighting, even in temperate zones, since the time of Xenophon. Its depredations were reported during the American Revolutionary War; its incidence and influencing factors were described in the Napoleonic War; and it played a significant role in the Crimean War. Most recently in the Falkland Islands conflict, "trenchfoot" exacted a significant toll on both sides. The British had 220 cases requiring evacuation from the field. On the Argentine side, 275 troops were hospitalized and most required some degree of amputation. While we have made monumental progress in combat technology between WW I and the time of the Falklands crisis, the incidence of soldier debilitation from cold injury remains a problem. Modern medical research is focusing on development of antiperspirants to keep footwear dry, reconditioning techniques to improve peripheral blood flow and other enhanced treatment procedures for cold injuries along with procedures to predict individual susceptibility to cold injury.

Heat. Hot, humid climates pose a special danger to troops. Injuries to soldiers, ranging from heat stress to heat stroke, can occur when operating in jungle or desert conditions. Even in a temperate theater such as Europe, heat casualties may abound. During WW II (1942-5) there were 35,398 admissions to hospitals and quarters for heat effects, with 238 deaths. The Vietnam conflict also provided much evidence that poorly-hydrated, unacclimated soldiers frequently capitulated to heat injury where well-hydrated, well-conditioned soldiers fared much better. The most serious danger associated with heat injury is the rapid rise of core body temperature accompanied by cessation of sweating (heat stroke). Soldiers that experience varying degrees of heat injury may exhibit listlessness, disorientation, headache, nausea and a general feeling of malaise. Prolonged patrols and/or field operations conducted in hot environments result in an increase in fluid loss through perspiration and respiration. Fluid intake is necessary to ward off the adverse effects of dehydration. Forced hydration permits the body to continue work and minimizes fluid deficit and electrolyte imbalance. The importance of forced hydration was proven in Vietnam, where troops observed water discipline and drank fluids frequently in order to prevent dehydration. A heat-injured soldier is a less effective combatant, and in most cases is a combat loss, at least temporarily. In many situations where a soldier has experienced a prior bout with heat injury, he is more likely to develop the same debilitating symptoms more quickly if subjected to a subsequent extreme heat exposure. For this reason, the Army has stressed acclimatization and physical conditioning in its jungle and desert operations training in hopes of reducing the incidence of heat injury in troops. Heat injury can be prevented in many instances, or at least controlled within acceptable limits for military situations, by the application of known preventive measures. Future research will provide the commander in the field tools to: better adapt troops to physical work in heat; provide adequate nutrition and water allowances; and avoid over-fatigue and heat stress.

Altitude. Exposure of soldiers to high terrestrial elevations frequently results in reduced military performance as well as medical disabilities which are incompatible with the successful completion of military operations. Altitude sickness renders soldiers physically and mentally incapable of performing vital military tasks. Altitude exposure may cause vertigo, mental disorientation and unconsciousness in addition to life-threatening pulmonary and cerebral edema. Soldiers operating in a high altitude environment must be conditioned to meet the mental and physical demands of their operational environment. High altitude operations call for excellent physical conditioning, increased caloric (carbohydrate) requirements and adequate acclimatization to combat hypoxia and fatigue. Future research will focus on treatment and prevention of Acute Mountain Sickness, and pulmonary and cerebral edema.

Musculoskeletal Training Injury. Musculoskeletal injuries incurred as a result of training, during both initial entry training and unit training, are a leading cause of morbidity in the peacetime Army. Most of these injuries are of the overuse type; e.g., stress fractures, Achilles tendonitis, and muscle strains. Although the rate of sick call visits is approximately the same for injuries and illnesses, the rate of limited duty (LD) is substantially higher. During initial entry training at Ft. Jackson in 198 and Ft. Benning in 1997, over 5 times as many days of LD resulted from training-related injuries (40-90 days LD/100 trainees/month for injuries vs. 8-18 days LD/100 trainees/month for illness). Among infantry soldiers in unit training at Ft Drum, the LD rates for injury were 10 times higher than for illness (112/100/month vs. 11/100/month). Additionally, Patient Data System summaries from 1981 indicate that musculoskeletal injuries result in approximately twice the number of hospital days per case than infectious disease. Predisposing of risk factors for training injuries include: 1) higher amounts of running mileage, 2) low levels of physical fitness, 3) high levels of body fat, and 4) highly arched feet. The fact that many of these risk factors are preventable or modifiable, coupled with the increasing awareness that the traditional wisdom (e.g., flat feet lead to increased risk of injury, more running mileage is better) upon which most of our physical training and accession screening programs have been based may be suspect, suggests that increased research into preventive strategies can significantly enhance readiness and reduce training and health care costs.

Electromagnetic Energy/Non-ionizing Radiation. Although many of the hazards responsible for non-battle injuries are considered part of the environment (e.g. temperature, humidity, altitude), there are other systems-generated hazards that are likewise responsible for precipitating nonbattle injuries. Among

the most common systems-generated hazards are those associated with the operation of laser and microwave weapons and adjunct devices. Modern technology has provided weapons systems capable of destroying targets at longer ranges, while at the same time creating a whole new series of potential health hazards to soldiers and systems operators. Radar systems and microwave generators produce large magnetic fields which may prove harmful to those exposed to the electromagnetic energy (EME) for prolonged periods of time. The hazards associated with EME are characterized as thermal and athermal, and in laboratory animals cause distinct injuries, the severity of which depends upon several exposure parameters (e.g. power level, exposure time, pulsed vs. continuous wave exposure). Thermal effects of EME can cause localized heating to exposed body part(s). Whole body exposure can result in elevated body temperatures which can cause gross changes in cellular function and morphology and in some cases, may result in total cell and tissue destruction. Key organ systems normally function within a well-defined, rather narrow temperature range. When subjected to abnormally high temperatures, or even temperatures just outside their normal range, these organ systems display histological and physiological changes that are often accompanied by functional impairment.

Athermal effects operate to create subtle functional and physiological changes in major organ systems. Not uncommon are behavioral changes, forgetfulness, and inability to concentrate following peak power, pulsed EME exposure. Other organ systems (e.g. CNS, circulatory system, eye, and ear) exhibit a wide variety of different anomalies when subjected to EME. Soldiers and leaders must be cognizant of the tremendous hazard presented by microwaves, electromagnetic pulse and particle beam systems.

Laser weapons and systems are also widely present in the modern Army. Since the early 1970s laser adjunct devices in the form of range finders and designators have been used by troops in training and in combat. In some instances, the users have suffered injuries from improper use of the devices or because they were uninformed as to the hazards of laser energy. Many medical experts agree that the eye is probably the most important sensor on the battlefield. The rapidly changing modern fluid battlefield will require soldiers to utilize their visual sense to its maximum extent possible. "Seeing" the battle and possessing the ability to rapidly react to and anticipate enemy action will determine who most often wins a skirmish. The organ systems most seriously affected by laser energy is the eye. Depending upon the wavelength and power level of the laser source, intrabeam viewing of certain lasers can cause injuries ranging from temporary flash blindness to permanent loss of vision. Laboratory studies have shown that even low energy exposure from a pulsed laser can cause retinal burns and in some situations complete photocoagulation. While less debilitating physiologically, flash blindness from continuous wave laser sources can adversely affect a soldier's ability to track a target. However, the threat in modern warfare clearly points to use of lasers as "soft kill" weapons as well as adjunct optical augmentation devices. The prevalence of lasers on the modern battlefield will expose the contemporary soldier to a novel threat that can permanently blind those who are ignorant of the hazard and fight unprotected.

Health Hazards of Combat Systems. Soldiers are faced with additional systems-generated hazards in the form of vibration, blast and toxicological threats. Modern weapons platforms possess unprecedented firepower and range capability. One of the detrimental trade-offs of weapon sophistication is the increased potential to physically harm soldiers and operators of such systems. A soldier's ability to hear on the battlefield can be severely restricted when suffering from a blast-related permanent or temporary auditory threshold shift. Like wise, blast effects can be non-auditory and have adverse affects on the function of air-containing organs, such as the lung and gastrointestinal tract; they can cause debilitating somatic and morphological changes in organ structure and integrity.

In a similar vein, weapons systems produce explosions and burning, often giving off toxic fumes and gases that can be extremely hazardous to soldiers. The toxic by-products of these weapons systems pose a chronic health hazard to combatants and to crews serving complex weapons systems

Other nonbattle hazards are also present. Modern vehicles and aircraft are capable of operating in a number of different operational environments. Designed primarily for combat and combat support roles, these vehicles and aircraft are made rugged and often times little design consideration is given to operator and occupant comfort and survivability. Soldiers encounter vibration and impact hazards from operating and riding in military vehicles. Much consideration should be given to anthropometry, ergonomics and survivability when designing military equipment, in order to minimize systems-based nonbattle injuries.

Battle Injury

The effects of enemy weapons are the second most common cause of hospitalization, the most common cause of incapacitation (next to disease), and the first cause of death in war. Reduction of mortality (i.e., death) and morbidity (i.e., degree of sickness and injury in populations or individuals) from injuries received in battle is the greatest challenge to the military health care delivery system during combat; contemporary weapons on the battlefield pose an added threat to the soldier (i.e., see preceding paragraphs on nonbattle injury addressing the hazards of electromagnetic energy). The objectives are to treat the less severely injured and return them to duty as rapidly as possible and to provide those who are more severely wounded with the highest possible quality of life.

The effectiveness of combat casualty care, and confidence in it, has a direct impact on how well the combat force performs on the battlefield. The ability of the medical system to rapidly return casualties to duty through expeditious field treatment and definitive medical care is essential to maintenance of an adequate flow of trained and experienced replacements on the battlefield. Table II-3 presents statistics on injury rates and hospital days that demonstrate the effects of combat casualties in WW II and Vietnam.

Table II-3. Impact of Battle Injuries

U.S. Army	WW II So. Pacific (42-45)	Vietnam (65-68)
Total battle casualties	95,021	85,380
Rate/1000 men/year	31	85
Hospital days/case	129	65
Returned to duty	77 %	84 %
Died of wounds in hospital	4 %	2 %

Post-traumatic Shock and Metabolic Defects. Shock (hypovolemia), secondary to excessive bleeding, is the most common cause of death in severely injured soldiers. One of the most critical areas of treatment for combat casualties at all levels of military medical care deals with blood and blood products, i.e., for the replacement of blood following a hemorrhage. In Vietnam the problem of screening and maintaining sufficient quantities of blood to meet sporadically heavy demands was complicated by the short shelf life of stored blood. About 50 percent of the blood sent to Vietnam was lost through outdating. The burden on the medical logistics system of maintaining adequate supplies of blood was, and remains, immense.

Another problem in Vietnam was the extremely short storage time of the blood platelets needed for blood clotting in the combat casualty. Military personnel used as walking donors were the only source of platelets in a combat area. This walking blood bank is jeopardized today by the threat of HIV transmission.

In the absence of blood, plasma volume expanders have been used to restore and maintain blood volume so that circulation to vital organs can be maintained. In the past, human serum albumin was the colloid agent of choice, but was expensive and bulky; however, without oxygen-carrying capacity, plasma or volume expanders are no substitutes for whole blood.

History has shown that the survival and return to health of the combat casualty depends directly upon the degree to which the health of damaged cells can be preserved and restored. If sufficient oxygen is not provided to cells to maintain metabolic function, irreversible damage rapidly sets in. This is more serious for some organ systems than others. The most critical are the central nervous system, which has no regenerative capacity, and the renal system (i.e., kidneys), which must be functional to remove the waste products that further complicate recovery.

There are no means for directly treating the defects in cell function caused by battle trauma. The best solution is to prevent the occurrence of irreversible damage through effective resuscitative and stabilization methods. Maintenance of adequate oxygenation and tissue perfusion is the key to good prognosis. Blood substitutes and lightweight ventilators for use far forward and during the evacuation process are essential, as is drug intervention to prevent or arrest the destructive impact of metabolic defects.

Burns. Before WW II, little attention was paid to the burns incurred in battle. Ever-increasing mechanization, modern munitions, and nuclear and directed energy weapons have increased the likelihood of burn injuries. Burn treatment requires a huge investment of professional resources in terms of physicians, nurses, and laboratory personnel. A seriously burned patient requires several months' hospitalization and then months or years of reconstruction for functional or cosmetic purposes. In 1970, there were 185 such patients evacuated from Vietnam, and 200 more from the rest of the forces.

Maxillofacial Injury. In the past, injuries to the maxillofacial area have occurred in 15 percent of all battle casualties. Facial appearance and normal function constitute major components of the personal identity of an individual. This identity is altered when injuries produce facial disfigurement and loss of speech, sight, smell, or the ability to eat. The resulting psychological debilitation may be refractory to normal modes of adjustment and require prolonged psychiatric care.

Wound Healing. The process of wound healing in the soldier is not the same as in the highway accident victim or other civilian counterpart. Missiles and missile fragments carry dirt and debris into the tissues and cause varying degrees of tissue damage. In the process of evacuation, the wound may be exposed to further contamination. Thus greater emphasis must be placed on debridement. As a result of the greater risk of infection, these wounds have to be left open initially.

To illustrate the magnitude of the resulting loss of manpower, consider that approximately one-half of all combat casualties have had multiple superficial missile wounds not affecting vital structures. Because of the danger of infection, these wounds have had to be left open initially, and could not be closed safely until they were determined to be uninfected at the end of 5 days. At the peak Vietnam war rate of about 500 men wounded per week, 250 men spent 5 extra days each in the hospital, for a total of 1,250 man-days per week or a loss of 65,000 man-days in a year -- the equivalent of 3-4 infantry divisions.

Reparative Surgery and Transplantation. Another major problem of Vietnam combat casualties was the destruction and loss of body components -- cells, tissues, vital organs, or entire limbs. These combat casualties presented a great challenge to the military surgeon who performed reparative and reconstructive surgery. The cost of their acute and long-term care was enormous.

In some instances loss of supportive structures could be corrected by use of prosthetic materials. For other injuries, the ideal replacement was freeze-dried preserved human tissues such as bone, cartilage, fascia, tendon, and dura. However, some tissues could be replaced only with living tissue grafts.

Vietnam pointed the way for the field of preservation and transplantation of those tissues and organs, which would have prime importance in the treatment of combat casualties. A lesson learned was that stockpiles of human tissue grafts must be developed to meet the needs of future combat medical care.

Nervous System Injury. Head injuries, spinal cord injuries, and peripheral nerve injuries have been very common sequelae to combat exposure; 40-60 percent of soldiers with head wounds died in the hospital. In addition, approximately 50 percent of those surviving penetrating head injury developed epilepsy that was Service connected. Spinal cord injuries that cause paraplegia or quadriplegia have a direct cost to government (VA hospitalization plus compensation) over the course of the veterans' lives. The Army had about 1500 paraplegics and quadriplegics in Vietnam.

Biological Warfare (BW) and Chemical Warfare (CW) Agents. The capabilities of many Third World countries and terrorist groups to produce biological and chemical agents pose a potentially serious threat to the United States. For example, in 1983, a Belgian company was alleged to have exported 500 tons of thiodiglycol to Iraq. This chemical, when combined with hydrochloric acid, produces mustard in excellent yield. Clearly, the synthesis of sulfur mustard is within the capability of any Third World country. However, this threat is not restricted to commonly known agents. Novel agents may be developed by potential adversaries. The ability to prevent BW and CW casualties through effective prophylaxes is essential to maintaining initiative and momentum in combat.

American losses due to CW agents in WW I represented 2.5 percent of "died in wounds" and "killed in action." In 1918, however, 30 percent of the "wounded in action" were caused by CW agents. Table II-4 reports the number of losses by country for the duration of the war.

Table II-4. Losses From CW Agents During WW I

Country	Poisoned	Dead
Germany	200,000	9,000
France	190,000	8,000
Great Britain	189,000	8,100
Austro-Hungarian Empire	100,000	3,000
Italy	60,000	4,600
Belgium and Portugal	10,000	1,000
Russia	475,000	50,000
U.S.A.	73,000	1,500
TOTAL	1,297,000	91,200

In extending Table II-4 to include hospitalization, the figures for U.S. troop time lost in the hospital during treatment for gas poisoning in WW I amount to 2,947,199 days, or 16.8 percent of all time lost in hospitals from battle injuries. The average amount of time lost for each patient admitted for gas poisoning was 42 days. Of the gassed patients whose injury did not prove fatal ~34,000, or ~47.2 percent were on sick report for less than 29 days, the average time lost for this class of cases being ~13.5 days.

Historical examples of the use of BW and CW agents in warfare include: the Germans' inoculation of horses (with glanders) and cattle (with anthrax) for shipment to the Allies during WW I, the death of 700 victims, according to the International Scientific Commission, as a result of Japanese attempts to use

biological agents in 1940-1944; the use of toxic material in the Yemen Civ.. War in 1967; the use of chlorine in 1915 and mustard gas in 1917 by the Germans against the Allies in WW I; the development of the synthetic chemical poisons during WW II; and most recently, the employment of chemical munitions in Afghanistan and Laos in 1982, and by Iraq in 1986 to as late as 1988.

Medical Field Equipment. Medical diagnostic and life support equipment has been a vital part of the total care system for treating the combat casualty. Military operational concepts involving the wide dispersion of highly mobile tactical and support units dictate that the medical diagnostic and treatment capabilities be mobile, compact, rugged, and reliable.

The greater part of the medical hardware that supports civilian health services is too bulky or too delicate to transport to the field. The problem has been enhanced by the continuing need for more sophisticated equipment to provide improved patient care and complement the skills of physicians trained in modern facilities.

RETURN ON INVESTMENT IN MEDICAL R&D

Army medical R&D materiel and informational products have produced *actual* cost savings and the *potential* for cost savings as well as an increase in mission effectiveness. Potential cost savings may be realized through the projected availability of future medical products. Table II-5 presents a few selected examples of the operational benefits and cost savings realized as a result of the accomplishments of medical R&D.

Table II-5. Selected Examples of Operational Benefits and Estimated Cost Savings of Medical Accomplishments

Accomplishments	Operational Benefits	Estimated Cost Savings
	DISEASE	
Malaria prophylaxis	Sustains operations in many areas of the world	$85.5 M between 1966-1969 (then dollars). (Mobilization and deployment costs for replacement troops would have been substantially more)
Development of Mefloquine	Chloroquine-resistant malaria can be treated	$20 M/year in direct medical costs
Adenovirus vaccine -- combined use of oral enteric coated adenovirus types 4 & 7 vaccines reduced ARD rates by 50% and adenovirus ARD rates by 95%; Licensed by FDA, these vaccines have been effectively used on all U.S. training posts since 1971	Reduces training/mobilization delays through reduction of recycling of recruits in basic	$7.5 M between 1970-1971 (then dollars) in hospital costs alone
Meningococcus vaccine – reduced incidence of meningitis in training environments by more than 95%	Basic training conducted any time	$7 M/year (not included are manpower and related cost savings)
Approval of Doxycycline to treat leptospirosis and scrub typhus	Jungle training in Panama uninterrupted and safer, Troops deployed to the Pacific Basin can be protected	$12 M/year in terms of operations in Panama, $60 M/year in endemic scrub typhus areas
Developed and implemented AIDS screening	Eliminated accession into Army of infected recruits	$33 M/year in Army health costs saved ~$190 K/recruit, $152 M/year saved by DoD screening out 800 AIDS-infected recruits/year

Table II-5. Selected Examples of Operational Benefits and Estimated Cost Savings of Medical Accomplishments (continued).

Accomplishments	Operational Benefits	Estimated Cost Savings
	DISEASE (continued)	
Test of arenavirus vaccine in Argentina	Successful test can potentially remove another group of viruses as offensive threat	$8 M/year in deployed troops
Testing of 1st gen broad spectrum antiviral drug	Ability to treat at least 2 highly fatal viral diseases occurring in areas of U.S. interest	$5 M/year in troops deployed in endemic areas
Alphavirus vaccine	Removed an entire group of viruses as an offensive threat	$22 M/year in troops deployed in endemic areas
Q-fever vaccine	Removed a highly effective weapon from adversary's arsenal	$92 M/year in troops exposed to the weapon
	NONBATTLE INJURIES	
Glaucoma research (epinephrine therapy)	Army pilots returned to cockpit	$72 M in training costs through 1974 (then dollars)
Physiological optics advances	Reduction in Army helicopter crashes and crewmen's lives lost	$100 M between ~1968-1971 (then dollars)
Health hazard assessments conducted for all new Army systems	Reduction in soldier and operator injuries resulting from impact, vibration, toxic gases and radiation hazards; safe fielding of prototype and emerging systems	$40 M/yr
Hazard protection	Formulation and development of new soldier protective equipment; soldier productivity enhanced; incidence of injury from extreme climates, mechanical forces and toxic threats	$70 M/yr
Performance effectiveness	Increased physical work capacity; enhanced physical training efficiency and reduced training injuries; improved system design through ergonomic considerations in new systems	$100 M/yr
Improved treatment of neuro-psychiatric injuries	Sustained human effectiveness; reduced evacuation	$70 M/yr (~1970, then dollars)
	BATTLE INJURIES	
Advances in vascular surgery and new materials for vascular grafts	Fewer amputations	In 1970, $162 M in lifetime VA costs saved (then dollars)
Improved protection from ballistic fragments and directed energy (B-LPS)	Reduction of ballistic fragment and laser-related injuries; reduced evacuation	$20 M/yr
Maintenance of a strong laboratory diagnostic base	Prevents threat and technological surprise	

The primary purposes of military medical research and development are the preservation of life and health and the maintenance of forces in the field. However, there is probably no other DoD program like medical R&D, whose research results are so applicable to the civilian community, both domestic and international. Advances in anti-malarial drugs, vaccines for a dozen diseases, blood and tissues substitutes, and the treatment of trauma are all of direct and present benefit to people everywhere. For example, DoD medical research teams in Egypt, Ethiopia, Taiwan, Indonesia, Thailand, Malaysia, and Vietnam have worked directly on civilian health problems that are not only threats to the future deployment of American troops, but also present scourges to the native populations.

Disease

Vaccines such as those developed by the USAMRDC to reduce training and mobilization delays caused by epidemic outbreaks of infectious diseases are essential to building and maintaining operational readiness. These vaccines have reduced the incidence of acute respiratory diseases and meningitis in training environments by more than 95 percent. Figure II-3 graphically demonstrates the significant savings that have accrued not only in lives saved but in health care costs avoided. Furthermore, the development of vaccines and drugs effective against such militarily significant diseases as hepatitis, shigellosis, and salmonellosis (diarrhea and dysentery) will maximize the operational capability of deployed troops.

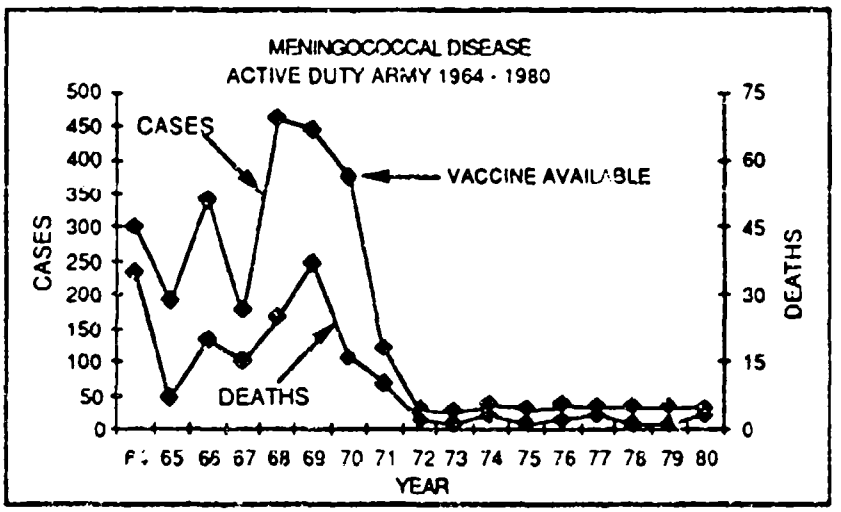


Figure II-3. Benefit of Meningococcus Vaccine

Perhaps no other research on a current medical threat offers the potential for dollar savings payoff as that of the AIDS epidemic. Contrasted to the annual requirement for AIDS R&D of approximately $40 million per year over ten years, the potential return on investment of $150 million each year in perpetuity is significant. Already the Army is benefiting from the highly accurate screening assay procedures developed by the USAMRDC at a rate of approximately $44 million per year from preaccession eliminations alone.

Nonbattle Injury

The return on investment in Medical R&D in support of reducing nonbattle injuries can be measured in both concrete and abstract terms. While there are numerous examples of reduced injury and lives saved because of R&D accomplishments, there are also examples of enhanced soldier task performance, improved man-machine interface and an overall added dimension of safety for soldiers and systems operators.

Combat Stress, Neuropsychiatric, and Continuous Operations Hazards. Research psychiatry has been increasingly coordinated within the services and considerable progress has been made in reducing such costs to the military. With an improved theory and knowledge of combat psychiatry, soldiers with combat fatigue can now be treated as close to the combat situation as possible. This one strategy has reduced psychiatric evacuations from a level of about 23 percent of all medical evacuations during WW II to less than 5 percent in Vietnam. Research on the causes of psychiatric breakdown has led to major changes in how we train and man our units to improve unit cohesion and stress resistance (the Unit Manning System) and how we manage combat psychiatric casualties to minimize long-term disability and hasten return-to-duty (Combat Stress Control Units as part of Medical Force 2000).

Exercise Physiology. Research in exercise physiology has contributed to enhancing the basic health, appearance, and performance capacity of the soldier through better selection, standards and training. The overall soldier fitness in today's Army is markedly improved as a direct result of research-derived physical screening tests for fitness and body composition, as well as balanced and efficient physical training programs which include all needed aspects of fitness. Optimum mixes of strength and aerobic training have led to rapid improvements in military task performance, such as loaded road marching and repetitive lifting. Health has been improved through the development of cardiovascular screening methods for the older Army population. Exercise physiology studies of the physical demands of Army occupations can lead to better matches between individual capacity and occupational demands.

Military Ergonomics. Research in military ergonomics has provided payoffs in determining the degree and nature of physiological tolerance limits for soldiers at work under the environmental and terrestrial extremes of military operations. This program identifies strategies and evaluates techniques for extending these limits by training, acclimatization, conditioning, or use of materiel aids such as clothing, drugs, and nutrients. Information on the mechanisms and effects of dehydration and rehydration has been provided to doctrinal and materiel developers. Recently, research has identified the importance of adequate sleep to proper body temperature regulation during physical exertion as well as the performance enhancing effects of red blood cell infusion during heat exposure. Physiologically based performance evaluations have been conducted for chemical warfare agent pretreatment compounds and antidotes, as well as microclimate cooling systems and toxicological protective clothing ensembles. This research program has led to the development of a hand-held heat strain calculator which can forecast sustainable maximum work times, work-rest cycles, and associated water requirements for individuals based on user input of clothing ensemble, physical work intensity and environmental conditions. Future work is planned to extend the capability of this predictive modeling technology to cold and high altitude environmental extremes.

Environmental Stress and Performance. Research in this area has helped to quantify the separate and interactive effects of environmental stress and operational factors on military performance. Basic neural mechanisms underlying the performance of military tasks have been studied to understand the process of performance degradation during environmental and operational stress. Subsequent research has developed interventions which prevent performance degradation and enhance performance under operational and environmental stress. Most recently, a series of studies demonstrated that the administration of tyrosine, an amino acid neurotransmitter precursor, may reduce or even prevent certain performance impairments of hypoxia and cold in soldiers subjected to abrupt changes in high terrestrial elevations. This suggests that during wartime, treatment with tyrosine may reduce the impact of adverse environmental conditions and other types of acute stress among soldiers engaged in combat and combat support activities.

Military Nutrition. Nutritional support of the combat soldier has been emphasized during the recent redesign of the Army Field Feeding System. Rations and food delivery systems have been designed and tested to support high levels of physical and mental performance in the soldier. Rations designed to support unique performance criteria in sustained operations, extended surveillance missions, cold weather operations and short but intense conflicts have been developed and tested. Nutrition programs designed to improve the cardiovascular health of garrison soldiers have been evaluated in a series of nutritional assessment studies in CONUS Army Garrison Dining Facilities. These initiatives have resulted in a reduction of fat and cholesterol consumption by soldiers subsisting in Army Dining Facilities.

Directed Energy Protection. State-of-the-art laser eye protection has been developed and is being issued to contingency forces. The ballistic-laser protective spectacles (BLPS) are designed to protect against two laser wavelengths commonly used in the training environment and against small grain, low velocity ballistic fragments. The BLPS will reduce the incidence of ballistic and laser eye trauma and will minimize lost duty time because of eye injuries. Additionally, the BLPS provide the soldier with a psychologically superior edge in knowing that he/she is protected from known eye hazards in the training environment.

Health Hazard Assessment (HHA). By conducting a health hazard assessment of new and emerging Army systems, the soldier is afforded a safe "head start" prior to the fielding of any new piece of equipment. HHAs identify and categorize all known hazards in any new or planned system. By analyzing the hazards, engineers and medical researchers can arrive at suitable alternatives for reducing or eliminating hazards prior to development of the prototype system. While some hazards are inherent in the design of a system, the end result of the HHA process sees the soldier operating a system that has been "hazard-proofed" to minimize hazards. HHAs in support of the M198 howitzer resulted in the successful fielding of that system. Additionally, extensive studies have been conducted in support of a wide range of ballistic platforms to ensure that blast-related hazards are minimized during system operation. Safety in Army systems may be a combat force multiplier.

Battle Injury

The return on investment in combat casualty care is much harder to measure in terms of readiness, mission capability, or dollars saved than that from infectious disease research. The cost of human life is undeniably great, but difficult to assess. Certainly benefits accrue from returning wounded soldiers to productive status; consider the savings in time and costs associated with training replacements for those who are returned to duty. But on pure cost and operational effectiveness bases, successful defenses against infectious disease provide a steadier return of soldiers to duty. Perhaps the most important payoff of effective combat casualty care is the hardest of all to measure – the positive impact on morale.

An increase in the casualty rate can mean either more wounded men or more survivors who reach medical care -- in Vietnam, the latter was the case, as shown by a decrease from 27 to 17 deaths per 100 men injured as a result of hostile action (IRHA) from WW II (1942-1945, South Pacific) to Vietnam (1965-1968). Rapid helicopter evacuation to major medical facilities after initial surgery or stabilization offered significant advantages over previous evacuation methods (although advanced air defense systems put the future of safe aeromedical evacuation in jeopardy).

The handling of shock was so superior in WW II that it is estimated to have caused a 35 percent decline in total mortality as compared to WW I.

Surgical research has reduced the mortality rates in battle. For those men admitted to hospitals for wounds, 4 percent died in WW II, and 2 percent in Vietnam.

The evolving natures of the combat environment and operational concepts dictate new requirements for field medical care and support equipment. The operational requirements of AirLand Battle (ALB) and

Army 21 demand that medical units be more mobile and self-supporting. An example of research, development, test and evaluation (RDT&E) efforts to decrease reliance on external logistics support is the development of a system to produce resuscitative fluids in the battlefield environment. This system will reduce 15-day resupply requirements for a four-division corps from 24 C-130 aircraft loads to a load carried by a single aircraft.

Figure II-4 illustrates how combat casualty care impacts the breadth and depth of the combat zone.

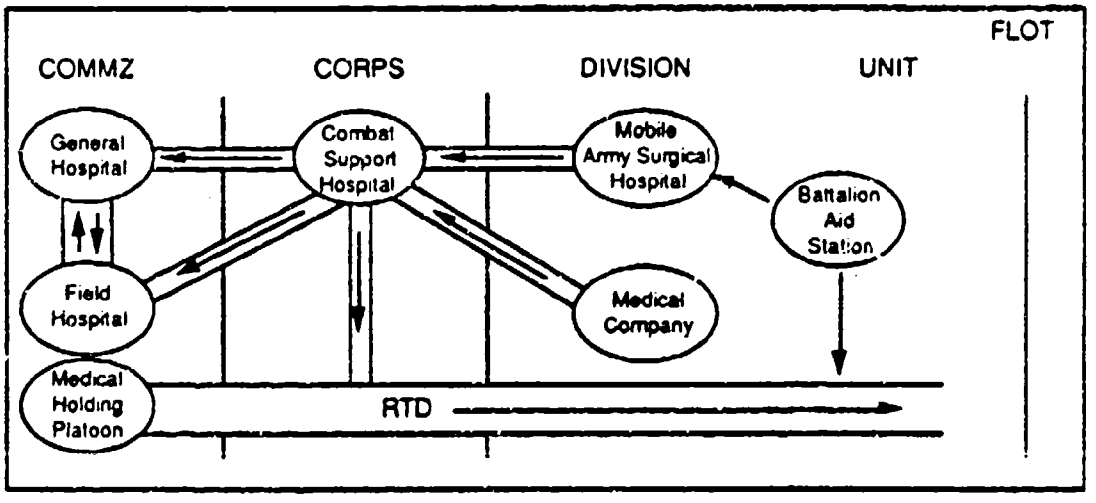


Figure II-4. The Emphasis of Combat Casualty Care is on the Combat Zone

IMPACT OF MEDICAL R&D ON WARFIGHTING CAPABILITY

The conduct of battle is highly dependent on many different factors. Modeling involving computer simulation and wargaming has been used to demonstrate the contributions of medical materiel and information products to the accomplishment of military objectives. An effective analysis strategy has been developed from a hierarchy of models that represent different levels of the battle. In this hierarchy, the largest scale is represented by theater level models such as the Integrated Warfare Force Evaluation Model (IWFORCEM) and the lowest scale is represented by small unit and company level models such as the Army Unit Resiliency Analysis (AURA) model. In this scheme, the effects of changes at the small unit level are generated and used as inputs into the next level of models. Figure II-5 shows where AURA is positioned in the hierarchy of wargames.

The objective of the computer modeling described here was to assess the impact of medical R&D materiel and information products on the Army's warfighting capabilities at the company/battalion level. Army standard models have been found to be sensitive to: a reduction in casualties, a decrease in severity of casualties, an increase in tolerance to the battlefield environment, a reduction in the number of troops and the time that the troops are away from the unit for medical care, and the increase in medical capability that reduce the logistical burden by cutting back the required replacement rate.

To begin the process of quantifying the benefits and potential benefits of the medical research and development program to general warfighting capability, a study plan was developed. The AURA model was chosen to represent company level units. AURA estimates unit effectiveness by considering the

state of personnel, equipment, operational conditions, and environment; unit effectiveness being defined as the unit's ability to obtain an optimal level of performance on its assigned mission and expressed as a percentage of the Army Training and Evaluation Program (ARTEP) standard. In looking across the spectrum of the battlefield, five units typical of Central European situations such as developed in the Scenario Oriented Recurring Evaluation System, Europe V (SCORES EUROPE V) were selected. The company level units were: an artillery unit, an attack helicopter unit, an infantry unit conducting anti-armor operations, a brigade level headquarters unit, and an ammunition supply point. These units have established data bases which have been refined by the U.S. Army Ballistic Research Laboratory with the appropriate Training and Doctrine Command (TRADOC) schools and centers.

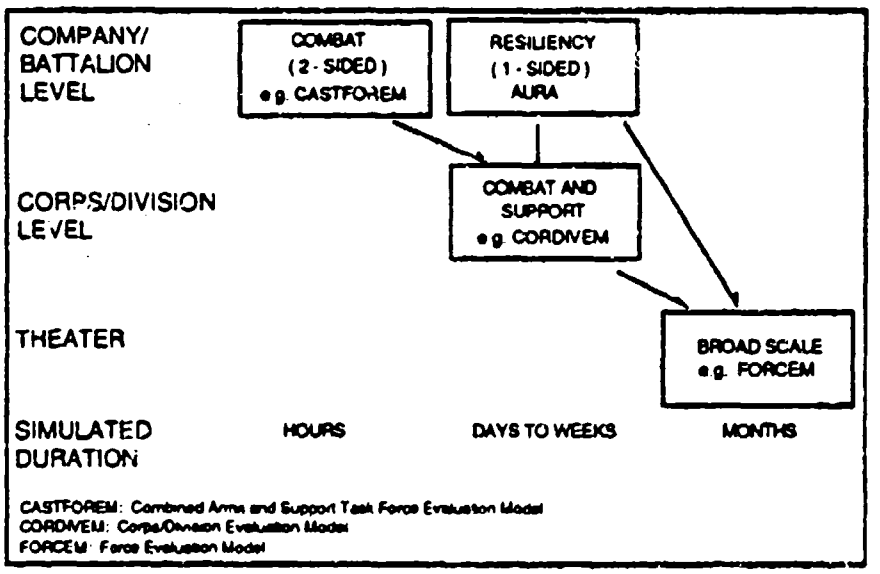


Figure II-5. Army Unit Resiliency Analysis (AURA) in the Hierarchy of Wargames

The selection of the input parameters was developed based on the characteristics of the products being modeled. AURA is highly sensitive to personnel degradation factors: casualty rates, task performance effectiveness, and return-to-duty rates. Therefore, input parameters were selected to represent the impact of medical R&D products in mitigating the adverse consequences on personnel degradation factors of selected battlefield hazards: chemical and biological threat agents, infectious diseases, operational and environmental extremes.

The specific interventions modeled included pretreatments and antidotes for nerve agent (soman), vaccines and drug prophylaxis for potential biological agents (Rift valley fever, Junin fever, Q fever, and tularemia), vaccine and drug prophylaxis for Malaria, sleep disciplines for continuous operations, and work/rest cycles for high thermal stress environments. In each case, unit effectiveness with the medical intervention was compared to unit performance using current doctrine and equipment.

The modeling conducted to date has shown significant benefits of many medical R&D products. For this presentation, pretreatment and anticonvulsant therapy for soman, vaccine and post-exposure prophylaxis for Junin fever, and sleep discipline during continuous operations were selected to display the variety and extent of improvements in warfighting capability.

Chemical Agent Hazard

Figure II-6 depicts the results of a chemical warfare attack by soman-filled artillery rounds. The effects are portrayed for an attack helicopter unit. The unit was in Mission-Oriented Protective Posture (MOPP) 0 at the time of the attack and immediately went to MOPP 4; personnel returned to MOPP 0 at "all clear" (~60 minutes). After the attack there were no personnel replacements except for chemical casualties that returned to duty. No conventional weapons effects were portrayed. The medical interventions compared were no therapy (squares), atropine plus 2-PAM therapy (circles), pyridostigmine pretreatment plus therapy (diamonds), and hypothetical anticonvulsant combined with pretreatment and therapy (triangles). All treatments prevented the expected 17 percent lethalities, but all treatment regimens temporarily incapacitated flight personnel for the first two days after attack as a side-effect of atropine on vision. The results demonstrate a dramatic improvement in unit effectiveness starting two days after attack compared to unprotected personnel. Pyridostigmine pretreatment, therapy and anticonvulsant restored unit effectiveness to over 80 percent. Pyridostigmine pretreatment combined with atropine and 2-PAM requires 21 days to restore effectiveness to over 90 percent. The anticonvulsant added to this treatment regimen (pyridostigmine, atropine and 2-PAM) restores effectiveness to over 90 percent in four days. With no medical intervention, the unit is at best 60 percent effective 21 days after attack with no potential for further improvement without fresh replacements.

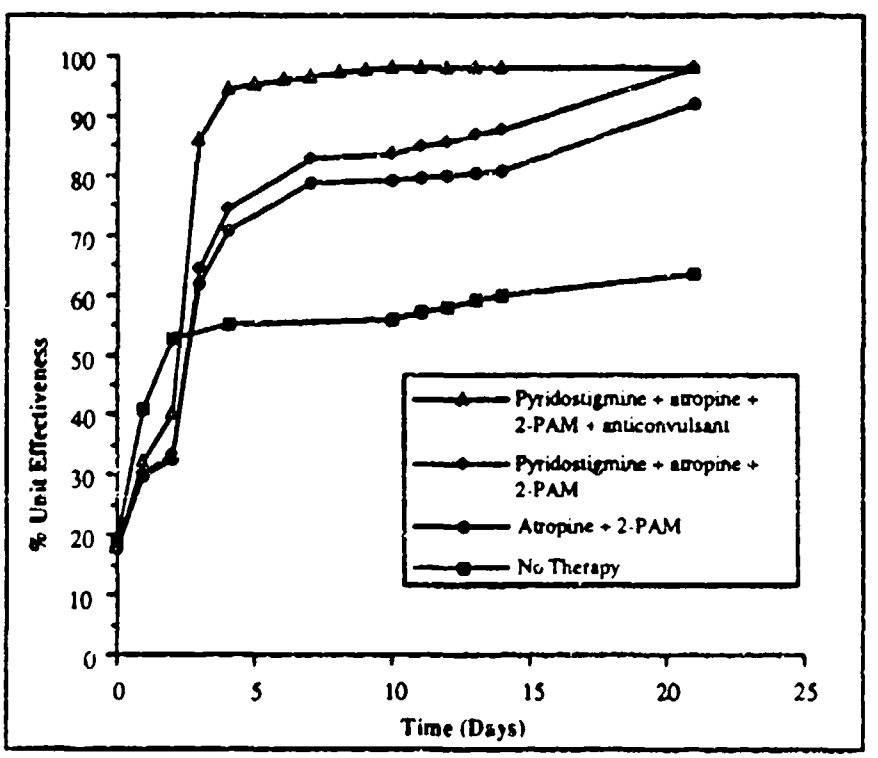


Figure II-6. Attack Helicopter Unit - Single Artillery Attack with Soman with Medical Intervention

Biological Agent Hazard

Figure II-7 depicts the results of the AURA modeling of unit effectiveness following an aerosol exposure to Junin fever (Argentine hemorrhagic fever). The effects are portrayed for an infantry company in anti-armor mission. In unprotected troops, such an exposure is expected to have a 100 percent infection rate with an incubation time of 7-16 days. The majority of symptomatic cases would be ineffective for a period of 7-25 days and 15 percent of the cases would be fatal. The medical interventions compared were no intervention (boxes), vaccine prophylaxis (diamonds), and ribavirin post-exposure prophylaxis (circles). Both the vaccine and ribavirin dramatically improved unit effectiveness compared to the medically unprotected by reducing the number of fatalities and incapacitated personnel. While the vaccine must be administered prior to exposure, ribavirin must be given after exposure and before the onset of symptoms. The benefits of ribavirin require timely diagnosis and logistics support immediately after exposure. In addition, ribavirin creates an incapacitating effect on some personnel. This scenario demonstrates the very significant benefits of an aggressive and well-planned vaccination program in the context of potential biological agent exposure. Protected units can be expected to remain 85 percent effective, compared to unprotected units that are reduced to less than 20 percent effectiveness for 12 days and never regain more than 80 percent effectiveness without fresh replacements.

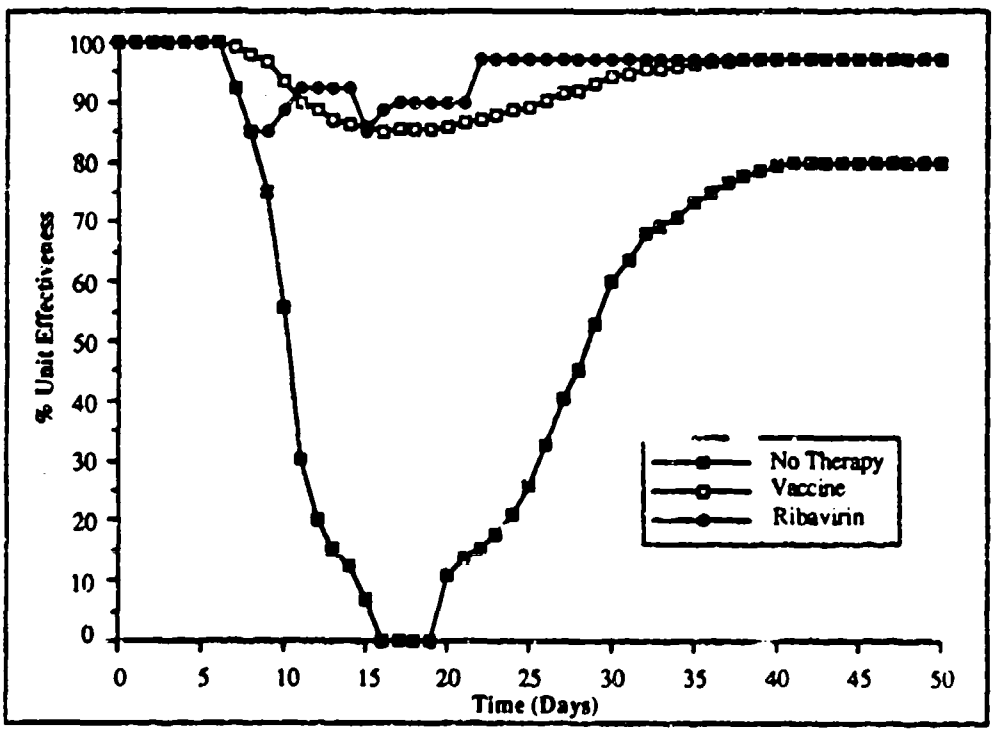


Figure II 7: Infantry Anti-Armor Unit - Junin Fever with Medical Intervention

Operational (Systems) Hazards

Figure II-8 depicts the results of AURA modeling of sleep discipline doctrine as it drives unit effectiveness -- portrayed in terms of the daily output of rounds per day by an artillery unit during continuous operations. Sleep requirements were represented by a normal distribution with a mean of 6

hours and a standard deviation of 0.75 hours. The job specific fatigue effects were based on an average decrement of 25 percent per day. The sleep regimens compared were four, six and seven hours of sleep per day. The results indicated that after four days of operations, the group given seven hours of sleep per day (and performing the fewest hours per day) generated the largest daily output of rounds. This is the consequence of progressive performance degradation that occurred with less sleep per day. Six hours of sleep can sustain a high level of performance for at least ten days; however, four hours of sleep cannot sustain a high level of performance for more than four days. This analysis demonstrates the direct contribution of medical research on sleep to Army allowances for soldier sleep requirements, force structuring, doctrine, and Army planning for continuous and sustained operations (FM 100-5 and 22-9).

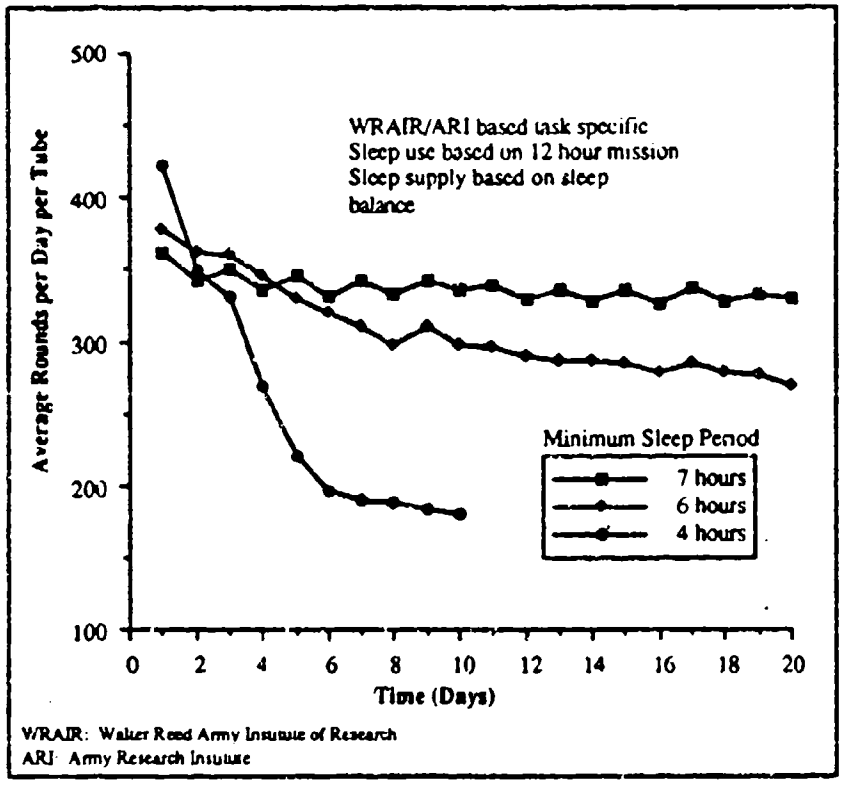


Figure II-8. Artillery Unit - Effectiveness During 24-Hour Operations

SUMMARY

Advances in Army medical R&D significantly impact the warfighting mission by conserving the fighting strength of our soldiers and supporting the nation's global military strategy. Army medical R&D products (materiel and non-materiel solutions) provide the foundation that ensures the fielding of a flexible, sustainable, modernized force across the spectrum of conflict and in the full breadth and depth of the battlefield. Countering diseases and other medical threats has provided a significant increase in military effectiveness in the past and presents the potential for future enhancement on military operational effectiveness.

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Section III

INFLUENCES SHAPING MEDICAL R&D PROGRAMS

INTRODUCTION

The development and execution of medical R&D programs are influenced by considerations from many sources. Primary sources are:

- The Army Long-Range Planning System (ALRPS), which guides planning for functional and special areas of the Army and describes worldwide trends and influences;
- The Army AirLand Battle Future umbrella concept, which incorporates the implications of the future battlefield for R&D;
- Army 21, which considers implications beyond AirLand Battle Future;
- The Health Services Long-Range Plan (HSLRP), which provides guidance to the Army Medical Department (AMEDD);
- Intelligence, threat assessment and documentation, which provide continuing guidance for focusing of R&D programs on the most urgent requirements;
- The Army Concept Based Requirements System, which formally identifies the requirements having the greatest importance to future warfighting capabilities;
- Geopolitical and Regulatory influences, which affect execution of necessary R&D programs; and
- Advocacy issues, which divert resources from execution of R&D programs.

Each of these sources influences the Army's Planning, Programming, Budgeting and Execution System (PPBES) in which finite resources are matched to the multitude of current and future requirements.

THE ARMY LONG-RANGE PLANNING SYSTEM

The Army Long-Range Planning Guidance (ALRPG)

The ALRPG is the lead document in the Long-Range Planning System which directs change within the total Army. It guides the operation of the Army CBRS and initiates periodic course corrections as required. The current ALRPG is the senior leadership's vision of the Army for the planning period 1998-2006. It presents broadly applicable guiding principles and worldwide trends and influences. The ALRPG also is specific enough to provide direction to each of the functional and special areas of the Army. The ALRPG is supplemented by functional documents such as the AMEDD's Health Services Long-Range Plan.

Figure III-1 summarizes the Army leadership's predictions for the three levels of conflict, from low intensity military operations short of war to high intensity conflict involving nuclear exchanges.

Level of Conflict*	Implications for the Army
LOW-INTENSITY CONFLICT. Full range of political-military activity short of conventional war: propaganda, psycho-social pressure, legal action, front group activity, intimidation, espionage, sabotage, terrorism, armed insurgency, subversion, and narcotics trafficking. Increased use of chemical weapons expected. Terrorists and insurgents will be as well armed as the Third World governments they oppose.	- Show of force, humanitarian aid, security assistance, peacekeeping, rescue operations, evacuation of U.S. nationals, joint and combined operations - Terrorism counteraction - Insurgency support and counterinsurgency - Psychological operations and political warfare - Limited use of conventional forces to protect U.S. interests and when UN/other treaty organizations are unprepared to act - Operations in chemical and biological environments
MID-INTENSITY CONFLICT. Constrained by linked political objectives, will use the most modern technology in C3I, service support, mobility, and firepower. Other constraints are possible: operations limited by geography, use of specific weapons, maximum troop strength or time limit (e.g., War Powers Act). Regional conflicts conducted by increasingly ideologically motivated forces prepared to fight to the limits of national endurance.	- More capable adversaries - Ability to win quickly in a fast tempo, highly lethal war regardless of constraints - Unconventional warfare - Joint and combined operations - Chemical warfare operations including pre-treatment of own troops - Logistics capability to support high rates of consumption in austere theaters
HIGH-INTENSITY CONFLICT. All means of waging war, including use of nuclear weapons. Increased number of nuclear-capable adversaries.	- Dependence on alliance solidarity - Radiation sickness prophylaxis - EMP hardening for all critical equipment - Joint and combined operations - Mobilization base sufficiency - Adequacy of national stockpiles
* Definitions from current authoritative sources are modified here to reflect potential changes over time.	

Figure III-1. Key Implications for the Future

ALRPG Planning Trends: Implications for Medical R&D

Figure III-2 summarizes some of the more important trends described in the ALRPG. Of these, several have particular importance for medical R&D.

- Regional Conflicts Will Become More Numerous. Given the expected shift in focus from Europe to less developed areas of the world, the significance of the adverse impact that endemic diseases could have on the ability of U.S. Forces to deploy and sustain combat operations will grow, not diminish.

- Nuclear, Biological, and Chemical Weapons Will Continue to Proliferate. Recent events have established chemical weapons as the "poor man's" strategic weapon. Given the relative ease of producing massive quantities of biological weapons for an even smaller capital investment and the difficulties inherent in effecting enforceable sanctions and controls, expanded use of these weapons is predicted.

- The U.S. Military-Age Manpower Pool Is Shrinking. Demographic projections indicate that the average age of active-duty service members is likely to increase, thus presenting a different set of challenges for military medicine. Additionally, intense competition is expected with colleges and the private sector for high school graduates, a situation that mandates close attention to the "ease-of-use" factors in design of new medical equipment and technologies for the battlefield.

- Operations Short of War Will Predominate. Civil assistance or "nation-building" missions will often include combat service support units operating independently, and with reduced logistic support. Furthermore, these units must be equipped with the materiel and knowledge to counter the health threats of Third World countries without making these countries dependent on the United States for long-term support. This Third World mission can benefit from increased attention by the USAMRDC and its overseas laboratories.

- Modern Warfighting Technology Will Proliferate. Conflicts in the Falkland Islands and Southwest Asia have clearly demonstrated that U.S. Forces are likely to face modern weapons regardless of the adversary. Lasers and other directed-energy (DE) weapons might be in the arsenals of potential adversaries.

- Global
  - Military and Economic Parity Among Nations Increases
  - Regional Conflicts Proliferate
  - Nuclear, Biological and Chemical Weapons Proliferate
  - Arms Control Negotiations Continue
- Soviet Union
  - Continues to Project Global Influence
  - Remains Primary Threat to U.S. Interests
  - Perceived as Less Hostile In Europe
  - Continues Modernization
- National Outlook
  - Military-Age Manpower Pool Declining
  - Public Support for Military Eroding
  - Military Budget Facing Periodic Austerity
  - Industrial Base Shifting Offshore
- Technology
  - Continued Rapid Growth
  - Revolutionary Advances Probable
  - Increased Investment by Soviets and Regional Powers
  - More Widely Accessible
  - Rapid Insertion into Fielded Systems
- Battlefield
  - Increased Mobility and Lethality
  - Geographical Dispersion in Breadth and Depth
  - Simultaneous and Sustained Operations
- Army Imperatives
  - High Quality Soldiers and Civilians
  - Realistic, Intensive Training
  - Progressive Leader Development
  - Modern Warfighting Doctrine
  - Materiel Superior to Threat
  - Technological Superiority
  - Adequate Facilities

Figure III-2. Trends Shaping the Future, 1990-2006

The HSLRP, which is part of the ALRPS, provides guidance to the AMEDD in performing its wartime medical mission and in changing to meet future needs. The HSLRP is based on the ALRPG predictions of the Army operating environment early in the 21st century.

The HSLRP integrates the Army's medical planning activities into a single document that can be used by the USAMRDC and other commands' health services planners and allows for decentralized execution. The HSLRP provides a long-range vision of the medical requirements necessary to conserve the fighting strength of our soldiers and meet our country's national and strategic objectives for the year 2010. The plan is published by the Office of The Surgeon General (OTSG), Headquarters, Department of the Army (HQDA).

Because of the importance of the HSLRP to medical R&D planning, extensive excerpts are included in Annex C.

DOCTRINE

Army warfighting concepts are evolving to cope with the future battlefield. AirLand Battle-Future (ALB-F) treats warfare 15 years in the future, and Army 21 continues the growth to 30 years. Revolutionary changes in warfighting concepts that may occur are categorized as advanced concepts.

Operational Environment

The Army's present warfighting doctrine, AirLand Battle (ALB), is based upon the conduct of simultaneous operations over the full breadth and depth of the battlefield (Figure III-3). AirLand Battle-Future continues the trend of rapid action, increased mobility and lethality of forces, synchronized operations geographically dispersed in depth and breadth, and sustained operations over long periods.

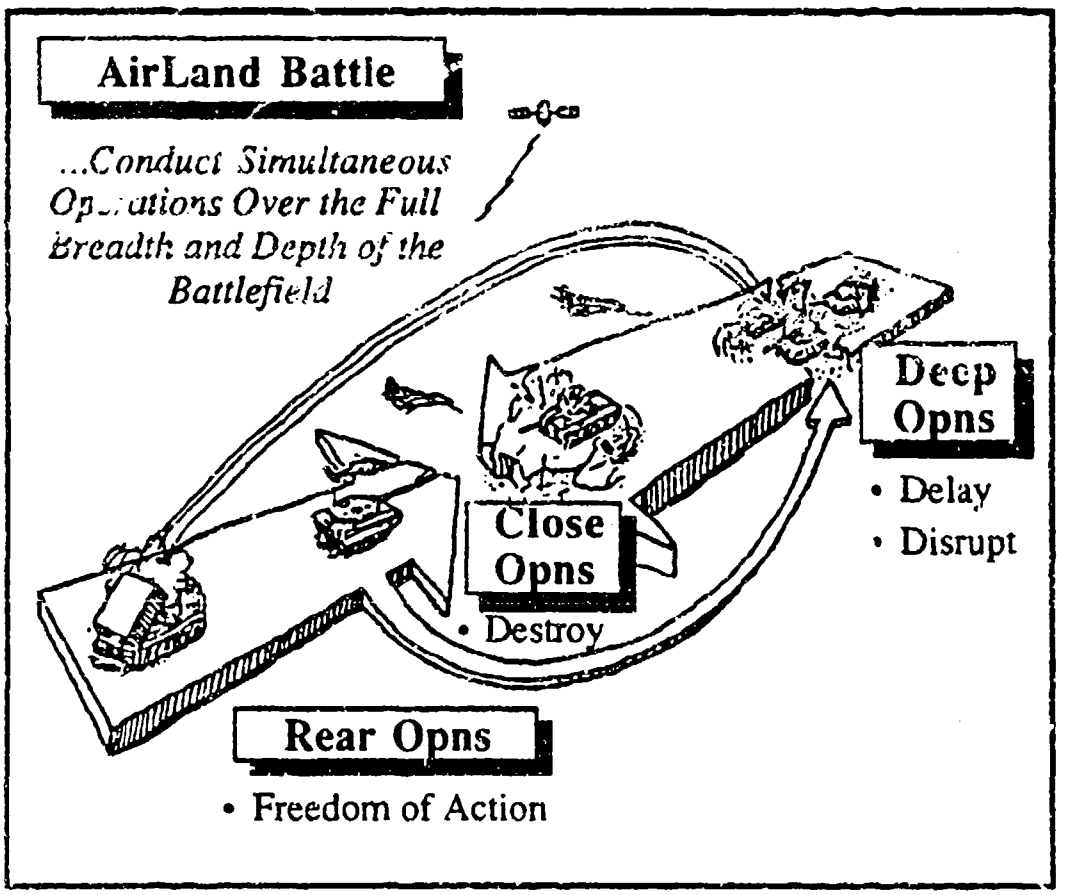


Figure III-3. Simultaneous Operations Over the Full Breadth and Depth of the Battlefield.

In a mid- to high-intensity conflict, improved capabilities will exist to locate and kill targets at greater ranges. Although forces will move rapidly, weapon systems with increased range and lethality will place both combat and noncombat forces at risk. Rapid and drastic changes in the situation and a diversity of combat methods will further complicate the battlefield. Future technologies and improved battlefield mobility may tend to dissect the battlefield into many small battles, with the intermingling of opposing forces nearly inevitable.

This battlefield environment will place new demands on the health care delivery system. Given the expected geographical dispersion of casualties and intermingling of forces, as well as the likelihood that enemy forces will have shoulder-fired weapons capable of interdicting air evacuation vehicles, far greater capabilities for far-forward casualty care must be available. Development of methods for resuscitation and prolonged stabilization without increased morbidity will be a major challenge for future R&D efforts. The likelihood that the users of these far-forward products will not be fully trained medical professionals further complicates the challenge.

The Strategic Environment

The ALB-F describes the capabilities the Army will need to conduct joint and combined operations in support of the nation's global military strategy early in the 21st century. Taking into account global trends and projected national interests, this concept lays out a strategy that is regionally based and that addresses both the combat and noncombat roles for the Army in the years ahead. Changing relationships among the superpowers and other nations over the next 15 years may require a change from a focus on Europe toward a more global perspective.

This concept looks ahead 15-20 years to determine what land force capabilities will be needed in regions of the world, based on our national interests and projected threats to those interests. Future joint military missions, as part of our national deterrent strategy, are predicted from these regional assumptions. Probable missions for the Army can be forecast similarly. This concept may lead to recognizing the need for greater strategic flexibility to improve our deterrent capability and provide credible opposition to the hostile influences in the world, thereby providing a more effective means for ensuring our national survival and a more stable world.

This planning process leads to the identification of more capabilities, forces, and systems than are available today or will be in the future, if projected constraints materialize (e.g., zero real-growth budget, inadequate strategic lift). For now, this process permits us to identify the capabilities needed regionally, establish priorities based on our national interests, and structure the land component of the military force accordingly. This analysis is the starting point for identifying the Army's requirements for the future.

In the ALB-F analysis, conflicts other than superpower confrontation are less threatening to our national survival, but these conflicts and their unfavorable outcomes could have a significant impact on our national interests as well as those of our allies. Consequently, the key to dealing with these situations is identifying and understanding the problem, anticipating its strategic impact and applying the elements of national power in the correct balance. Successful operations provide a means, consistent with our national will and capability, for reducing risks (i.e., removing threats that may result in military escalation) or making the threat more manageable. Military operations short of war are a complementary part of our national strategy and may have the greatest strategic impact in the next 15 years.

Use of Military Resources by Other Departments of Government

The Army may be required to support civil Government agencies in missions that potentially affect our national security and perhaps even our survival (e.g., drug interdiction). While the idea of Army support for an agency outside the DoD is not new, the number of missions and responsibilities is likely to grow. The

ALB-F identifies the capabilities that could be used by non-DoD agencies. The Army must show the relationship of these missions and capabilities to our national interests and assess their impact on training, organization, doctrine, materiel acquisition, leader development, and joint operations.

THREAT DOCUMENTATION

In broad terms, the definition of threat is the ability of a potential enemy or environment to limit or prevent mission accomplishment or to neutralize or reduce the effectiveness of a current or projected organization or item. The threat to a specific component of the Army is a statement of that component's capability. A threat then, to the Army, identifies vulnerability in the Army's capabilities and identifies a need for Army planning and development of concepts, doctrine, and materiel.

The threats that must be addressed in developing a responsive medical R&D program are described in a classified document entitled The Medical Mission Area Threat (MedMAT). The following (unclassified) planning assumptions indicate the scope of that document.

- Naturally Occurring Infectious Disease Threat. Endemic diseases will continue to be a significant medical threat to the Army. Past experience suggests that 60 to 90 percent of hospital admissions on the battlefield may be due to endemic diseases. The impact of Acquired Immune Deficiency Syndrome will need to be addressed.

- Environmental Extremes (Heat, Cold, and Terrestrial Altitude). Severe performance degradation may be caused by extremes in the battle environment. The success of military operations may be determined by which force does the best job of minimizing the negative impact of these extremes.

- Battle Injuries (Small Arms, Artillery Fragments, and Mines). The use of high-velocity projectiles, plastics and other nonferric materials, and new types of antipersonnel ammunition (e.g., caseless ammunition) and kinetic energy weapons will complicate the management and treatment of medical casualties with traumatic wounds from these weapons.

- Soviet Biological Warfare Threat. Soviet BW agents include pathogenic microorganisms and toxins intended to incapacitate, injure, or kill. The growing Soviet capability in genetic engineering could significantly complicate medical defense against BW agents that may be used.

- Non-Soviet BW Threat. Many Third World countries have the potential to develop and use BW agents.

- Soviet-Warsaw Pact Chemical Warfare Threat. The CW capability of the Soviet Union and its Warsaw Pact allies is formidable and may be augmented in the 21st century by the introduction of new chemical agents.

- Non-Soviet, Non-Warsaw Pact CW Threat. Additional countries will acquire chemical weapons or the capability to produce them by the 21st century. Iraq and Iran are known to possess CW weapons.

- Directed-Energy Weapons Threat. The primary DE antipersonnel threats are laser range finders and designators. With current technology the major health effects from laser radiation are eye injuries, ranging in severity from temporary flash blindness to permanent loss of vision. While current laser eye protection consists of lens filters to screen out laser radiation, enhanced protection will be needed to combat the frequency agile laser threat as that technology is fielded. High energy lasers will also constitute an antipersonnel threat as technology advances in field

energy production. Radio frequency (RF) and microwave (MW) emissions may also prove to be an antipersonnel threat requiring protection from electromagnetic emissions in these frequency ranges.

- Blast Effect Weapons (BEW). The use of BEW, such as fuel-air explosives, could significantly increase the number of primary blast casualties encountered on the battlefield. These casualties will complicate triage and treatment of battlefield casualties.

- Combat Stress and Continuing Operations. Continuous and sustained operations, and the increasingly lethal weapons systems being fielded by adversary forces, will add a significant component to the existing stress of combat. Additionally, other stress related hazards to the physical well-being of troops exist due to substance abuse, which poses a threat to both deployed and garrison troops.

- Nuclear Threat. Tactical nuclear weapons are a threat in the European scenario. In addition, Third World countries are likely to obtain nuclear weapons in the 21st century. A need for protection and treatment from the effects of these weapons continues.

- Health Hazards. Health hazards generated by our weapon systems, hazardous wastes and industrial pollution, and equipment will continue to be a concern in the Army's Materiel Acquisition Decision Process (AMADP). Protection against hazards such as combustion products and chemical compounds must be incorporated through engineering design, use of personal protective equipment, and administrative controls.

THE CONCEPT-BASED REQUIREMENTS SYSTEM

The Army has developed a comprehensive approach to attain its goal of balance among readiness, modernization, sustainability and force structure. This approach, called the Concept-Based Requirements System, was introduced in Section I and is shown schematically in Figure III-4. The CBRS is the primary system TRADOC uses to identify and prioritize Army warfighting requirements for doctrine, training, leader development, organization, and materiel (DTLOM). The focus of this effort is to produce an integrated set of force modernization actions within specified time frames. Distinctive products of the CBRS are the Army Modernization Memorandum (AMM) and the Field Long-Range Research Development Acquisition Plan (FLRRDAP). Linking to the Army's PPBES, the CBRS develops solution sets to identified needs, organizes recommended solutions into Capability Packages (CPs), analyzes the comparable cost-benefits of the solutions, and prioritizes them in the AMM.

Cross Mission Studies

The Combat Developer (CBTDEV) uses several tools to identify specific deficiencies or areas for improvement in warfighting. Capability Issues (CIs) for the future battlefield are developed and analyzed; i.e., the perceived threats, the envisioned battlefield scenario, doctrine, and the size and composition of the forces expected to be available. From these emerge descriptions of requirements for which solutions are sought through improved DTLOM. Changes in doctrine and training are the first choices considered, since they offer the lowest cost and quickest response. Throughout the CBRS process, Materiel Developers (MATDEVs) interact with the CBTDEVs to ensure full understanding of specific needs and to offer expert advice on the technological options, as well as development of materiel and non-materiel solutions.

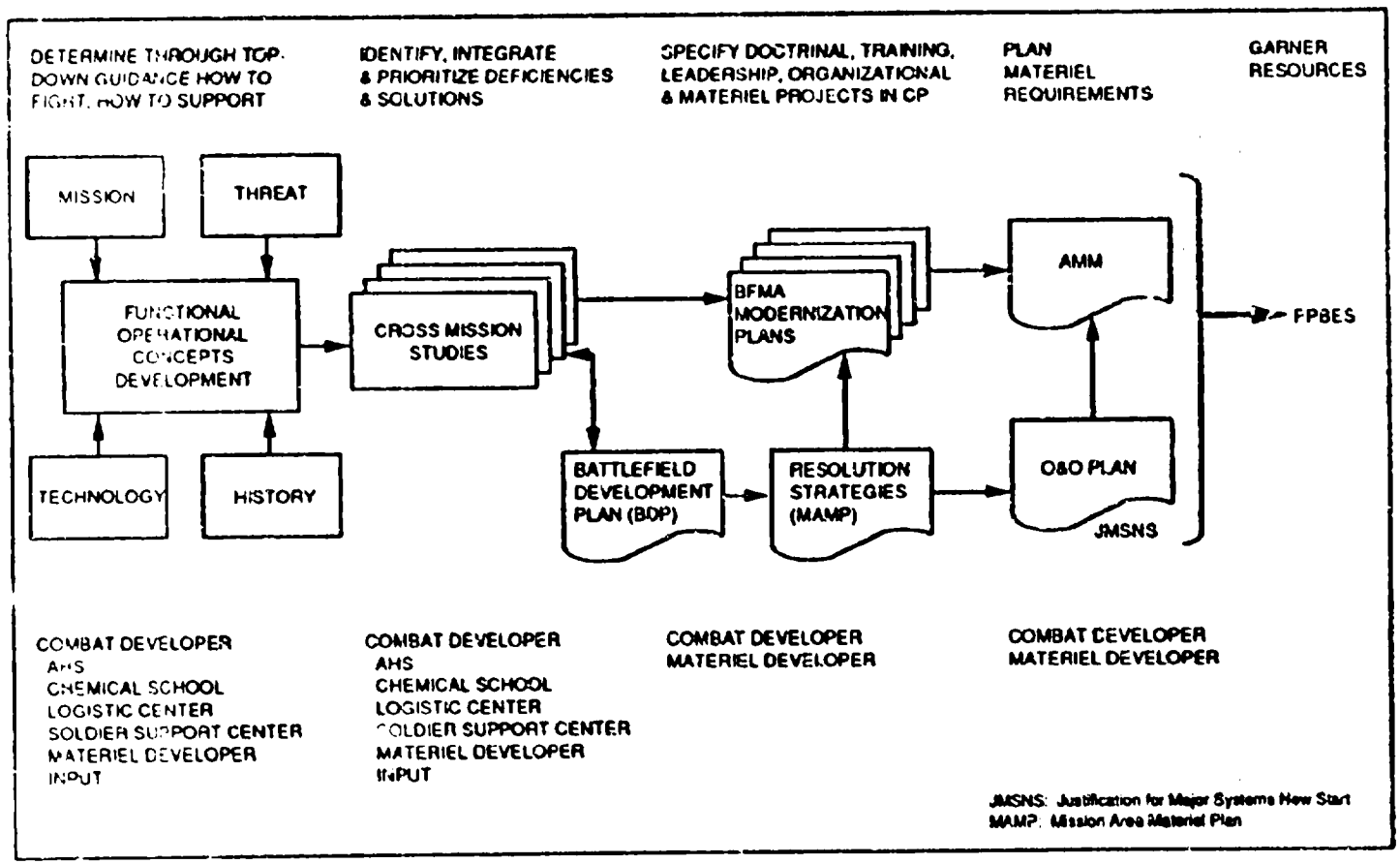


Figure III-4. The Army Concept-Based Requirements System

Battlefield Functional Mission Area Concepts

Warfighting concepts describe desired capabilities for the entire battlefield. Integrating centers expand upon warfighting concepts by developing concepts at the Battlefield Functional Mission Area (BFMA) level. There are seven BFMA concepts which provide additional detailed descriptions of how to fight on the future battlefield and provide the focus for the branch planning process (e.g., Armor, Chemical, Medical.) Under these seven BFMA concepts, there are twenty-nine CPs that address a standard capability for the Army across all force lines. The five BFMAs and associated CPs to which medical solutions contribute are shown in Figure III-5.

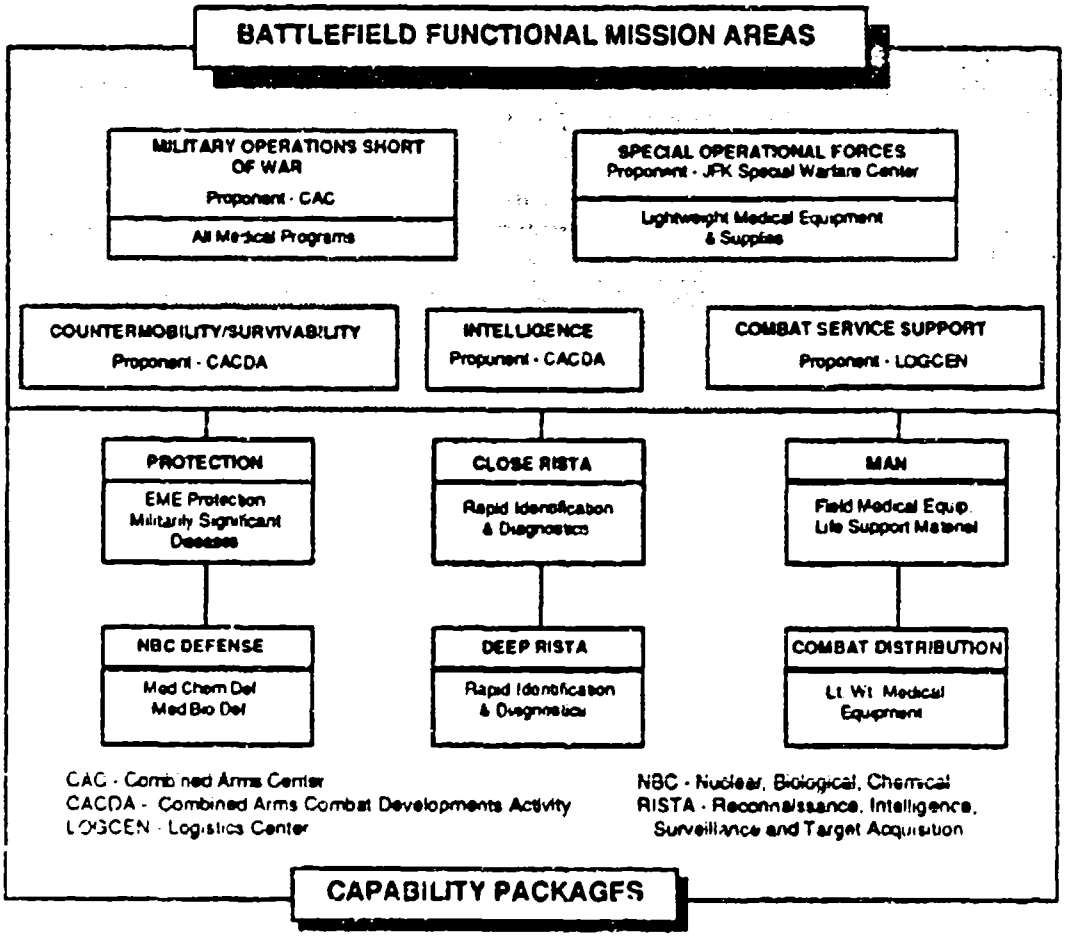


Figure III-5. Medical Interfaces with Modernized CBRS.

Required capabilities are determined through meetings with Subject Matter Experts (SMEs), and review of previous Mission Area Analyses (MAAs). Current deficiencies are determined for these areas. Through the establishment of performance standards, a difference in operational capability can be determined. This difference represents the AMEDD Capability Issues (deficiencies/efficiencies).

These analyses are performed under the direction of the TRADOC Deputy Chief of Staff for Combat Development (DCSCD) and the TRADOC centers and schools. The Academy of Health Sciences, as the primary medical CBTDEV provides medical CIs [formerly Mission Area Development Plan (MADP) CIs] to the Logistics Center (See Section VI). Solutions in the form of branch solution sets are developed once the CIs have been determined. Integrating Centers and the TRADOC group the solution sets by CP and integrate and prioritize the solution sets based on cost-benefit and trade-off analyses. These solution sets then become the basis for the AMM, which provides a comprehensive, constrained strategy for the Future Army. Solution sets for the CPs are generally presented as "Systems of Systems" (SOS). These SOS indicate items that should or should not be present for a system to function as designed. Table III-1 shows the AMEDD's SOS and the corresponding Management Decision Packages (MDEPs) and program elements.

Table III-1. AMEDD Systems of Systems and Corresponding MDEPs/Program Elements

SOS Health Service Support System - Includes all doctrine, training, leadership, organization, and materiel (including research, development, and acquisition) to provide stabilization, evacuation, medical treatment, medical regulation, to treat all categories of casualties (i.e., wounds, shock, trauma, burns, combat stress, etc.) in all types of medical facilities, level I-IV throughout the theater, communication zone (COMMZ) and level V in the CONUS.

RJ21	-	Combat Service Support (CSS) Life Save
FL8D	-	Deployable Medical Systems (DEPMEDS) Equipment
RJ23	-	Frozen Blood/Replacement and Modernization
MSAZ	-	Other Medical Systems
63807 836*	-	Combat Medical Materiel Advanced Development
64807 832*	-	Combat Medical Materiel Engineering Development

SOS Medical Chemical Defense - Includes all doctrine, training, leadership, organization, and materiel (including research, development, and acquisition) to provide medical pretreatment, antidotes, personnel decontamination, and casualty care unique to the treatment of chemical casualties.

64807 848*	-	Medical Chemical Defense Life Support Materiel
63807 993*	-	Medical Defense Against Chemical Warfare

SOS Medical Biological Defense - Includes all doctrine, training, leadership, organization, and materiel (including research, development, and acquisition) to provide preventative methods such as vaccines and pharmaceutical prophylaxes and casualty care materiel unique to the treatment of biological casualties.

63807 809*	-	Medical Biological Defense Drug/Vaccine
64807 847*	-	Medical Biological Defense Engineering Development

SOS Infectious/Endemic Diseases Affecting Military Operations - Includes all doctrine, training, leadership, organization, and materiel (including research, development, and acquisition) to provide preventive methods such as vaccines and pharmaceutical prophylaxes and casualty care materiel unique to the prevention of infectious and endemic disease casualties.

63807 808*	-	DoD Drug & Vaccine Advanced Development
64807 849*	-	Infectious Disease Drug/Vaccine Engineering Development

SOS Medical Nuclear Directed Energy Defense - Includes all doctrine, training, leadership, organization, and materiel (including research, development, and acquisition) to provide medical actions taken to prevent injury or reduce the vulnerability of friendly forces to the adverse effects of Army systems to include the research, development, and acquisition of medical materiel.

* These Program Elements/Projects are included in MDEP RJ22.

The Battlefield Development Plan (BDP)

The BDP is generated by TRADOC to consolidate results of cross mission studies. It describes the battlefield environment forecast for the Army, highlights the doctrine used in the analysis, and assesses the Army's capability to survive and win on the battlefield. The BDP assessment cuts across mission area lines and the TRADOC prioritized list of deficiencies. The BDP provides the relative priorities of all deficiencies, identifies non-materiel problems, and identifies critical materiel deficiencies for the development community. The BDP is a bi-annual planning document that guides technology base prioritization processes performed jointly by HQDA, each MATDEV, and each CBTDEV. This process supports the development of the Army Long-Range Research Development and Acquisition Plan and guides the MATDEVs in preparing the Mission Area Materiel Plans. The AHS, as the medical CBTDEV, ensures that the AMEDD's requirements receive full consideration in the BDP.

The Mission Area Materiel Plan (MAMP)

The purpose of the MAMP is to prioritize product development programs according to their ability to address materiel requirements in the AMEDD CIs and BDP. The MAMP presents a comprehensive description of R&D projects and the combat requirements they address. The CBTDEV is responsible for identifying mission needs (capability issues) based on Army doctrine and for determining when a CI has been satisfied. The MATDEV is responsible for maintaining the technology base and for managing the development of technology base products that can be fielded within given resource constraints. Continuous coordination between the CBTDEV and the MATDEV is required to develop and maintain a MAMP that matches products to CIs, reflects priorities that are consistent with CI importance and resource constraints, and represents a jointly developed strategy for achieving program goals and addressing mission CIs.

The Medical Mission Area Materiel Plan (MedMAMP)

Annual review of advanced development R&D products through the MedMAMP links the CBTDEV (AHS), the MATDEV (USAMRDC), and the logistician (USAMMA). The MedMAMP prioritization of Army medical RDT&E programs against the AMEDD CIs and BDP ensures the necessary compliance with the CBRS. The Medical Research, Development and Acquisition (RDA) MAMP provides the framework for essential programmatic efforts: e.g., LRRDAPs; PPBES activities; and cohesive RDA strategies to overcome deficiencies in MAAs. Figure III-6 shows the relationship of the PPBES to the Modernized CBRS.

PLANNING, PROGRAMMING, BUDGETING, AND EXECUTION SYSTEM

The Army's principal tool for resource allocation is the Planning, Programming, Budgeting and Execution System. The PPBES provides the mechanism and the visibility required to fairly match limited resources with pressing requirements. It uses a sequential, analytical, and integrated approach in which budgets (real money) flow from programs (future money) and programs are shaped by the force requirements identified in the CBRS and by the need to develop and implement technology that meets those requirements.

Planning and the Long-Range Research, Development, and Acquisition Plan

The planning phase of the PPBES includes the ALRPS and the CBRS, and culminates in the LRRDAP for research, development and acquisition. The LRRDAP, with its 20-year view of programs and projects and their associated priorities, provides the foundation for matching resources to requirements for development, procurement and the technology base supporting them. The ATBMP Science and Technology Objectives (STOs) form an important part of the Army's top-down guidance for development of the LRRDAP.

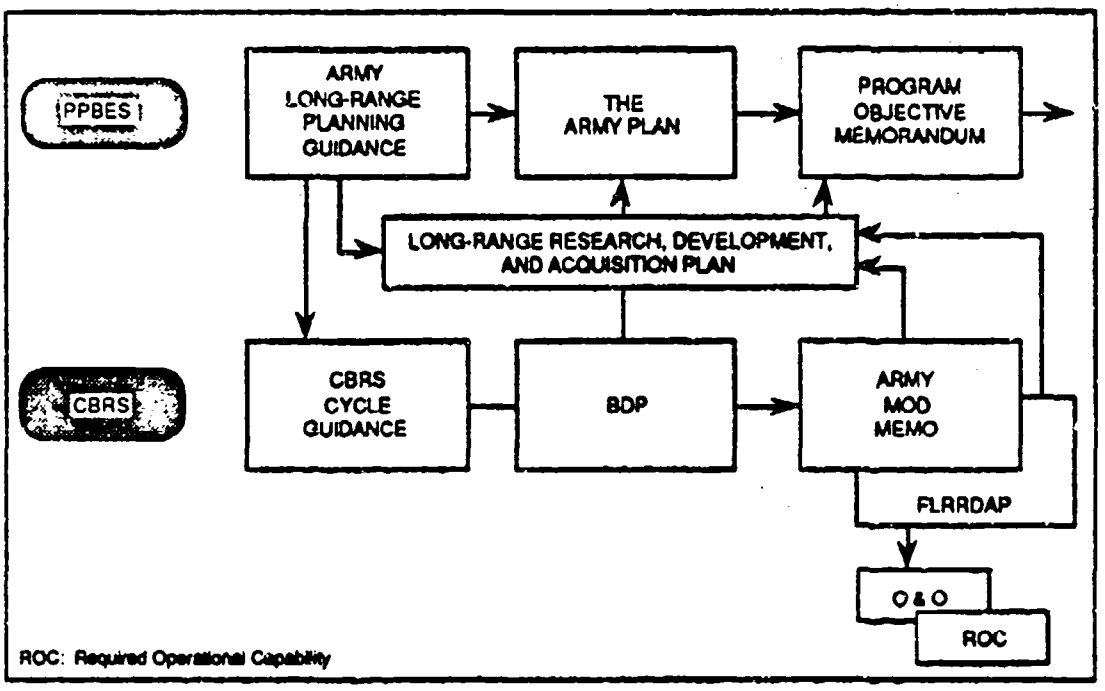


Figure III-6. Relationship of PPBES to CBRS

The LRRDAP displays R&D and procurement programs and individual systems that support the requirements that were identified and prioritized through the CBRS and the Army Modernization Memorandum. The LRRDAP provides a road map for the R&D community, stabilizes the RDA process, couples planning with the PPBES through the development of the Program Objective Memorandum (POM), and provides an audit trail of approved programming actions.

The field LRRDAP is developed using guidance provided by HQDA and prioritized based on those CIs identified through the CBRS process and the AMM. This guidance is derived from the ALRPS, the requirements of the warfighting CINCs, and specific program and funding guidance provided by HQDA. Technology base guidance is provided by the Director, Research and Technology, Office of the Assistant Secretary of the Army for Research, Development, and Acquisition [OASA(RDA)], and is based on the investment strategy published in the ATBMP, including the Army's STOs. The field LRRDAP evolves into the Department of the Army (DA) LRRDAP during a series of intensive management reviews that allocate resources according to the established investment strategy. The reviews are conducted jointly by the LRRDAP proponents, OASA(RDA) and ODCSOPS, with participation from all interested HQDA staff elements, culminating in an Off-Site Review by senior Army leadership.

Programming and the Program Objective Memorandum

Once the Army leadership is satisfied that the LRRDAP applies available RDA resources to the most important battlefield needs, it becomes the basis for the equipping portion of the Program Objective Memorandum. The OASA(RDA) directs the development of the POM based on the priorities established in the DA LRRDAP. Review committees instrumental in this process are the Program Budget Committee (PBC) and Select Committee (SELCOM), which review and respond to program directors' defenses of assigned programs. The committees' exploration of the issues, risks and trade-offs, and final

recommendations to the Chief of Staff of the Army (CSA) and the Secretary of the Army are designed to ensure fair resource allocation, consistent with Army requirements and resource availability.

Budgeting

The budgeting phase translates the program need for dollars, facilities (Military Construction, Army [MCA]), and manpower into requests for Congressional appropriations. It has two stages: budget formulation and budget justification. In the formulation stage, a budget is prepared for submission to the President. In this process budget estimates are developed, reviewed, and adopted or modified based on resource availability and priority. The justification stage deals with Congressional review and approval of the budget submitted by the President. Budget justification includes review by the Office of the Secretary of Defense (OSD) for adherence to Defense Guidance, as well as participation in Congressional hearings to study the nation's defense posture and military management.

Budget Execution

The budget execution phase consists of commitment, obligation, and disbursement of budget funds for performance of approved programs. In addition to administrative control of funds and manpower, this phase covers the reporting of results and program status and the assessment of results for feedback into future plans, programs, and budgets. The OASA(RDA) reviews the status of obligations and disbursements during the budget execution year and reallocates funds from programs that do not meet established targets to those requiring additional funding.

Technology Base Versus Development in the Requirements/PPBES Process

The organization and mechanisms of the PPBES process make it easier to prioritize product-oriented development programs than technology base efforts. Nevertheless, the LRRDAP establishes the strategy for focusing technology on identified problems according to the priorities established during the CBRS process. In parallel with the CBRS process, the MATDEV must maintain a strong technology base for correction of future deficiencies and development of new capabilities. Thus the CBRS documents (e.g., BDP, MADP, MAMP) guide the development of technology base (6.1-6.3A) programs but do not completely constrain them, as they limit development programs (6.3B and 6.4). Because of the need to anticipate and deter new threats, the MATDEV is required to monitor intelligence reports, scientific breakthroughs, and threat assessments.

The principal documentation for technology base requirements is contained in the ATBMP. The investment strategy (Volume I) and the STOs (Volume II) guide the Army technology base community in planning and directing a research program consistent with the senior Army leadership's projections. The ATBMP and the CBRS have equal weight in the PPBES process. Current medical STOs are described in Section VI.

OTHER INFLUENCES ON MEDICAL R&D

Joint Service Responsibilities

The Army is the executive or lead agency for most DoD medical R&D programs. For those programs for which the Army is the lead agency, USAMRDC is responsible for planning, programming, and budgeting for research requirements for all the military departments, even requirements that are service-unique.

No single structure is prescribed for the management of all joint programs for medical materiel. A Joint Service Agreement (JSA), a Memorandum of Agreement (MOA), Congressional language or other

documentation may be used for managing a Multi-Service requirement. Several coordinating groups and committees have been established to assist in the management of RDA efforts related to chemical and biological defense materiels. In addition, informal information passes among the Services, largely through scheduled meetings of service representatives. The Armed Services Biomedical Research, Evaluation, and Management (ASBREM) Committee, discussed in Section V, is the primary forum for inter-Service coordination and planning in medical R&D.

A Joint Service Review Group (JSRG) coordinates programs for which the Army has responsibility for both medical and non-medical portions, such as chemical and biological defense. The JSRG, chaired by the Army's DCSOPS, recommends to the Services a joint plan that:

- Identifies the requirements of all the Services and recommends priorities for them;
- Recommends the MATDEV lead Service(s) for each requirement;
- Indicates the key milestones for the requirement; and
- Supplies fiscal and programming guidance to ensure that, within the constraints of resources available, the highest priority needs of all the Services are met.

Agreement on joint requirements for chemical and biological defense provides for the conduct of coordinated research programs by the Services. The JSA establishes goals that can be achieved within available resources, can meet the highest priority requirements of all the Services, and are compatible with the goals of Defense Guidance. Requirements addressed under the JSA can be either Joint Service, and thus the responsibility of the Army as executive agent for programming and execution, or Service-specific, remaining the responsibility of that Service. There are three types of requirements contained in the Chemical-Biological JSA that must be considered in planning for medical R&D programs:

- A Materiel Requirement (MAR) calls for fielding materiel for which the necessary technologies are available. MARs are addressed by Systems Advanced Development (6.3B) and Full-Scale Development (6.4) programs.

- A Science and Technology Objective (STO) calls for development and/or demonstration of the technology needed for a materiel item or family. STOs are addressed by Basic Research (6.1), Exploratory Development (6.2), and Non-Systems Advanced Development (6.3A) programs.

- A Chemical Data Need (CDN) calls for acquisition of data on the properties and effects of a chemical, biological or medical system. These data are needed for the development of doctrine, tactics, training, and materiel. CDNs are addressed by Basic Research (6.1), Exploratory Development (6.2), Non-Systems Advanced Development (6.3A), programs, force development tests and experimentation.

Joint Service Agreement medical requirements are cited in Annex D.

International Standardization Agreements

International Agreements establish cooperative programs with the North Atlantic Treaty Organization (NATO) and friendly non-NATO countries for developing advanced technologies. By these means, the Army reduces duplicative R&D and enhances rationalization, standardization, and interoperability with allied and other friendly nations. The USAMRDC will continue to explore more agreements for cost-sharing, as described under "Leveraging" in Section IV. The USAMRDC participates in the international programs described below.

Mutual Weapons Development Data Exchange Agreement (MWDDEA). These agreements, with their medical annexes, establish cooperative medical R&D data exchange programs and promote cooperative medical research. Contributions include: the review and evaluation of Chemical Defense

Programs; the review and evaluation of Biological Defense Programs; the determination and prioritization of initiatives that should be pursued; the evaluation of product interoperability; and the determination of product marketability. [Annexes to the Data Exchange Agreements (DEAs) are in place with many countries, including France, Germany, Israel, and Korea. There are several classified DEAs.]

NATO, Panel VIII, Research Study Group 3 (RSG3). The RSG3 investigates prophylaxis and therapy against chemical and biological agents. Contributions include: long-term study on defensive aspects of chemical and biological warfare; detailed investigation of CW agent casualties from the Middle East; and the standardization of test paradigms.

NATO, Panel VIII, Research Study Group 8 (RSG8). The RSG8 investigates the nutritional aspects of military feeding. Contributions include: agreed nutritional criteria for operational rations and garrison feeding; investigation of nutritional strategies to sustain physical and mental performance during prolonged operations and exposure to climate extremes; and agreed methodologies for nutritional evaluation of military feeding systems.

The Technical Cooperation Program (TTCP) Subgroup E. The TTCP agreement is among the United States, United Kingdom, Australia, and Canada. Subgroup E (Chemical Defense) includes Technical Panel 1, "Treatment of Chemical Agent Poisoning," and Action Group 32, "Field Therapy." Contributions by Technical Panel 1 are: a quad-Service casualty care exercise (U.K.); trial CHACE I and II (Canada); a medical management of chemical casualties course (U.S.); construction of a pyridostigmine data base (U.K./U.S.); construction of a physostigmine data base (U.K./U.S.); and collaborative research on HI-6 (U.S./Canada). Action Group 32 contributions are: cooperative programs in the management of CW agent casualties; and cooperative medical R&D initiatives in treating vesicant injury, field resuscitation, and preventing/treating chemically induced non-cardiac pulmonary edema.

U.S.-U.K.-Canada Memorandum of Understanding (MOU). This MOU establishes a cooperative program on the research, development, production, and procurement of chemical and biological defense materiel. Cooperative programs have been established to: maximize resource utilization, ensure standardized defense capability, provide technological assessment of emerging threats, promote timely sharing of data, and focus special program initiatives. Cooperative medical R&D initiatives have been established to: develop concepts for decontamination; explore countermeasures to emerging threats; devise prophylaxes, pretreatments, and antidotes; assess anticonvulsants; make casualty care estimates; and evaluate therapy.

The ABCA (America, Britain, Canada, Australia) Standardization Program. The ABCA Agreement is among the United States, United Kingdom, Canada and Australia. The objective of the ABCA agreement is to standardize, insofar as possible, doctrine, training, and materiel among the four armies. The program is accomplished by means of Quadripartite Working Groups (QWGs). TSG, AHS and the USAMRDC participate in the QWG Health Service Support (QWGHSS).

Regulatory Influences

Several regulatory agencies impose requirements that constrain the medical R&D process. These agencies have responsibilities for safeguarding the environment, protecting the health of the public, and overseeing the development of new medical products.

Food and Drug Administration. The FDA is the regulatory agency most involved in the AMEDD activity. The FDA is responsible for the regulation of all drugs, biologicals, and medical devices used in the United States, regardless of origin. It monitors these products from the pre-clinical investigations through the production, distribution, and long-term performance of the drug or device. The FDA is concerned with the effectiveness of the product as well as its safety.

The FDA requires adherence to Good Laboratory Practice (GLP), current Good Manufacturing Practice (cGMP), and Good Clinical Practice (GCP) guidelines. These standards for research, testing, and manufacturing cover personnel qualifications and training, project organization, facilities, quality control, and overall management. GLP applies to non-clinical safety studies; it specifies methods for their appropriate conduct and documentation. cGMP applies to synthesis, production, and manufacturing procedures; it establishes standards for product consistency and quality control. GCP applies to clinical safety and efficacy studies; it establishes standards for conducting human studies, protection of subject's rights, and proper record keeping. Documentation is required in applications to the FDA to assure that the guidelines are being or will be complied with and that every reasonable effort is being or will be made to meet compliance.

There are two points in the medical materiel development and acquisition process at which the USAMRDC is required, by statute, to obtain FDA approval: 1) before the initiation of testing in human subjects; and 2) before release of the product from investigational status. Moreover, the entire process of product development is subject to FDA oversight; the agency may intervene to request additional information; to inspect facilities, data, products or activities; or to require change or modification of procedures. The process differs for pharmaceuticals, biologicals, and medical devices.

U.S. Department of Agriculture (USDA). To develop preventive measures or treatments for zoonotic diseases that are not native to the United States, it may be necessary to import live cultures of microorganisms for study. This requirement is in direct conflict with the USDA mission of preventing the importation of exotic animal pathogens. The USDA publishes a list of microorganisms whose importation is banned. If the required microorganism is on the proscribed list, the USAMRDC must request an exception. If USDA approval is obtained, use of the organism is subject to stringent USDA safeguards that ensure against introduction of the disease into the U.S. ecology. If USDA approval cannot be obtained, the research must be conducted in an overseas area where the disease is endemic. In addition, the USDA administers the Animal Welfare Act.

U.S. Environmental Protection Agency (EPA). The EPA acts as the regulatory approval authority for new insect repellents, pediculicides, and clothing impregnates used in disease vector control. The EPA has varying levels of involvement in the development of biologicals, but no direct role in pharmaceuticals or medical devices. The EPA would be expected to closely monitor any biological material, but only rarely becomes involved with the AMEDD, except for development of repellents, clothing impregnates, and other pesticides used in disease vector control. Because virtually all of the biologic products developed by the AMEDD are vaccines and serums being prepared for human administration rather than release into the environment, it is unlikely that any of these might be an environmental threat. Nevertheless, Title 42, U.S. Code 4321-4337 of the National Environmental Policy Act of 1969 (NEPA) requires that the Army consider any possible adverse impacts on the environment prior to initiating any new research efforts, whether they involve biologicals or not. The appropriate level of documentation will vary depending upon the level of hazard.

Department of Labor, Occupational Safety and Health Administration (OSHA). The Occupational Safety and Health Act (OSHAct) of 1970 required OSHA to promulgate safety and health standards applicable to the private sector workplace. Section 19 of the OSHAct directed Federal agencies to establish comprehensive occupational safety and health programs "consistent" with the private sector standards promulgated by OSHA (29 CFR 1910). This mandate was emphasized in Executive Order (EO) 12196, Occupational Safety and Health Programs for Federal Employees, and in an implementing OSHA regulation, 29 CFR 1960, Basic Program Elements for Federal Occupational Safety and Health Programs. One of the elements called for the adoption of the OSHA standards or corresponding standards that provide at least equivalent protection. It also encouraged the development of applicable standards not addressed by the OSHA. Both EO 12196 and 29 CFR exempt uniquely military equipment, systems and operations. Nevertheless, the Army has recently requested OSHA inspection of some facilities.

Occupational safety and health program guidance is contained in DoD Instruction 6055.1, Department of Defense Occupational Safety and Health (OSH) Program; and DoD Instruction 6055.5, Industrial Hygiene and Occupational Health. These directives include provisions for safety and health standards and requirements covering the military-unique situations exempted by the Federal regulations. Each of the DoD components has published program documents that implement the DoD guidance. The Army program is outlined in AR 385-10, Army Safety Program; AR 40-5, Preventive Medicine Program; and AR 40-10, Health Hazard Assessment.

Department of Transportation. Standards are regulated for transportation of biologicals among DoD and civilian laboratories.

Other Regulatory Influences. In addition to responding to the previous agencies, the research efforts of the USAMRDC must also adhere to guidelines established by the NIH. Protocols involving recombinant deoxyribonucleic acid (DNA) are reviewed by the NIH Recombinant Advisory Committee (RAC) under the Office of Recombinant DNA Activities (ORDA). The guidelines on containment of biohazards established by the NIH through the Centers for Disease Control (CDC) dictate both facilities requirements and safety procedures for research using pathogens. An additional complication in the execution of a research program is Title 10 (Limitation on Use of Humans as Experimental Subjects), U.S. Code 980, which mandates special requirements for military research involving humans. Specifically, the requirements for obtaining informed consent are more restrictive for the military than similar provisions for human research in the private sector.

Politics and Public Opinion

Domestic politics is sensitive to the pressures of public opinion. These pressures act directly or indirectly to produce constraints or contingencies for the Army. The public opinion environment is both dynamic and uncertain. New factors come into play, while others fade away. The pace and magnitude of the changes in public opinion are sources of uncertainty and dependence for the Army.

The Army's medical defense programs are highly vulnerable to the pressures of public opinion in two ways. First, USAMRDC programs depend on research contracted to the academic community. The "stigma" of military research, plus the stigma of perceived BW or CW applications, render this contractor base vulnerable to political movements on college campuses. Second, citizens groups oppose aspects of the USAMRDC program, ranging from animal experimentation to chemical agent storage. Activities of these groups have recently resulted in limitations on wound research on animals. Given the initial successes of these geopolitical influences, the USAMRDC must consider the impacts these influences will likely have on its mission.

Each of the USAMRDC's research areas has been variously affected by public opinion pressures. For example, the Military Disease Hazards Research Program has been profoundly affected as a result of a lawsuit brought by the Foundation of Economic Trends. Under the terms of a court agreement, the USAMRDC was required to submit a programmatic Environmental Impact Statement (EIS) on the Biological Defense Program. Preparation of the EIS was a costly endeavor (estimated cost, $2.5 million) and the outcome of this suit may result in additional suits filed (e.g., CB Defense Program). The funding and manpower resources necessary to meet this requirement were drawn from the USAMRDC. AR 200-2 requires full consideration of the environment in the decision-making process.

Certain laboratory practices have been interrupted as a result of public opinion concerning animal use in research. In particular, the Under Secretary of the Army directed the AMEDD in 1986 to discontinue animal tests in the Bradley Fighting Vehicle. This prohibition of animal use in studying the combined effects of live fire, toxic gas, and blast overpressure has resulted in the use of empirical, predictive models based on laboratory research. These models cannot address the problem directly, nor can they take into account the synergistic effects of heat, blast, and toxic gases. Although attempts are being made to develop computer modeling as a substitute for live-fire testing, such models will not be available for many

years. Similar sensitivities are threatening continued use of animal models in combat casualty care research.

To preserve its ability to conduct research that can save lives and reduce the long-term debilitation of disease and injury, the USAMRDC must join with other organizations in the national medical R&D community in defense of responsible, necessary animal research. At the same time, each research project requiring animal models must be carefully scrutinized to weigh the knowledge to be gained against the need for use of animals in research.

The expansion of facilities for medical chemical and biological defense research programs is threatened by increasing social concerns about the environmental consequences of research. These concerns hamper the Army's ability to place new contracts with universities in certain areas, expand defensive chemical/biological agent research to in-house facilities, or continue research in existing facilities.

USAMRDC programs vulnerable to political interruption are continually assessed and their vulnerabilities addressed. These vulnerabilities fall into three categories. Some, such as studies of animal models, are inherent in medical research; some, such as handling of CW and BW agents, are inherent in the medical defense mission; and some result from DoD activities in the past. Some inherent problems can be ameliorated -- or at least not aggravated -- by management sensitive to the program's vulnerabilities. Unnecessary public relations blunders can be avoided.

Treaties and Conventions

The 1925 Geneva Protocol. The Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases and of Bacteriological Methods of Warfare was signed at Geneva on 17 June 1925 and entered into force on 8 February 1928. As of the end of 1985, 108 nations were parties to the protocol, including the five permanent members of the UN Security Council. Viruses are covered by the Geneva Protocol, but are not mentioned; they were not regarded as biological entities different from bacteria at that time. Further, in the legal context of the Geneva Protocol, the prohibition of "bacteriological methods of warfare" means a much broader prohibition of biological methods of warfare. Similarly, the language "bacteriological (biological) weapons" and "microbial or other biological agents" appears in the 1972 Biological Weapons Convention.

The 1972 Convention on the Prohibition of the Development, Production, and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction. On 25 November 1969, President Nixon announced a major policy decision on the U.S. chemical and biological warfare program. With regard to chemical warfare the U.S. forswore first use of chemical weapons but reserved the right to retaliate in kind. With regard to the BW program, the use of lethal bacteriological (biological) agents and weapons and all other methods of biological warfare were renounced, and the DoD was directed to make recommendations for the disposal of existing BW weapons. No retaliatory capability was to be maintained. This prohibition was extended to include toxin weapons in 1970. President Nixon further stated that the U.S. would confine its biological research to defensive measures such as immunization and safety measures.

The Convention on the Prohibition of the Development, Production, and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction was signed on 10 April 1972 and entered into force on 26 March 1975. As of the end of 1985, 103 nations were parties, including the U.K., the U.S. and the USSR, three of the five permanent members of the UN Security Council. The parties have agreed "never in any circumstances to develop, produce, stockpile or otherwise acquire or retain: (a) microbial or other biological agents or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective, or other peaceful purposes; (b) weapons, equipment, or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict."

SUMMARY

No matter how the global environment changes in the next 20 years, the principal tasks confronting the U.S. Army will remain deterrence of war by maintaining a credible warfighting capability, and defense of U.S. interests, if deterrence fails. To maintain adequate capabilities for deterrence and defense, the Army must plan for the future, program for the near-term, and set priorities for its annual budget, which always will be too limited for all contingencies. These issues must be addressed: which technologies to adopt, develop or forego; how to adjust organization and doctrine; how to develop battlefield leaders; how to train the Army under the constraints of rising costs and limited maneuver area; and, ultimately, how to satisfy the requirements of the combat commanders.

Today's system of Army planning depends on future projections. Whether these projections are near-, mid-, or long-term, they are needed for determining program and resource requirements to accomplish the health care mission. As such, long-range planning must be a continuous process.

The objective of the Medical Technology Base Master Plan (MTBMP) is to provide direction for the concept, materiel, personnel, and organizational developers. The intent is to enable the medical community to follow the logical progression from the ALRPG, ALB-F, the projected mission area threat, the HSLRP, and other planning influences to the development and funding of medical R&D programs in the LRRDAP and POM. Conversely, failure to provide effective medical countermeasures on the battlefield can lead to continued exposure to "war-stopping" threats.

Section IV

TECHNOLOGY BASE INVESTMENT STRATEGY

INTRODUCTION

This section describes the investment strategy that will be implemented to attain the goals contained in the Medical Technology Base Master Plan. It presents the foundations of the MTBMP and describes the issues upon which the medical technology base community will focus over the next 20 years. The medical Technology Base Investment Strategy (TBIS) implements and supports the Army TBIS.

The Army TBIS calls for the distribution of technology base resources to the following four areas, or domains:

- Emerging Technologies: Investment in 13 high-payoff technology areas that have the potential to significantly impact warfighting capabilities. Of these, biotechnology and neuroscience technology are of particular interest to the Army medical R&D community.
- Systemic Issues: Persistent, pervasive issues that do not focus on only one system or capability. For their effective resolution, these require continuing investment (e.g., soldier-oriented R&D, lightening the force, and medical logistics R&D).
- Supporting Capabilities: The technology base's contribution to the maintenance of the infrastructure that supports the technology development process (e.g., laboratory modernization, test facilities, special-purpose equipment and computers, testing technology, simulation and modeling capability, and assessment technology).
- Next-generation and Future Systems: Technology base investments (6.1-6.3A) that can be linked to specific preproducts or notional solutions rather than to emerging technologies or systemic issues. These include the technology demonstrations ("tech demos") required to qualify candidates for transition to development.

THE ARMY TECHNOLOGY BASE MASTER PLAN AND THE TECHNOLOGY BASE INVESTMENT STRATEGY

The Army Technology Base Master Plan

The ATBMP provides the foundation for the MTBMP. It describes the linkage between the nation's technology base and national goals that influence the Army. It contains the Army's official TBIS for realizing leadership's vision of future Army needs.

The ATBMP provides an assessment of the threat that the Army faces, and of the warfighting doctrine and concepts that address that threat. It highlights the importance of Army modernization plans to the implementation of those concepts, and it describes the linkage between the technology base and Army modernization plans, key emerging technologies, and basic research thrusts. It also discusses initiatives necessary to overcome lingering systemic/chronic issues, the need to maintain those capabilities upon which the technology base depends, and the interface of the Army technology base with other technology base communities

Volume II of the ATBMP (Classified SECRET) contains the Army's STOs. The STOs provide Army guidance to the technology base community. In addressing the STOs, the technical base community should manage their efforts in concert with that guidance and with a vision of the future Army. This guidance requires that subsequent technology base PPBES actions are in step with a unified vision.

The Technology Base Investment Strategy

The Army's TBIS is designed to provide the requisite Army capability across the full spectrum of conflict. The TBIS focuses 6.1, 6.2, and 6.3A resource efforts that ensure technological superiority for the Army in both materiel and knowledge on the battlefield. The strategy is based on the eight principles shown in Figure IV-1.

- Ensure technology base program supports Army's warfighting capability
- Balance technology base:
  1. Near-, mid-, and far-term needs
  2. Technology push/requirements pull
  3. Weapons systems/other requirements to sustain Army on battlefield
- Distribute technology base resources in four areas:
  1. Key emerging technologies
  2. Systemic issues
  3. Supporting capabilities
  4. Next-generation and future systems
- Seize and retain technology initiative through endeavors such as the Balanced Technology Initiative Program, competitive strategies, and technology forecasts
- Enhance return on investment by leveraging R&D outside the Army
- Speed fielding through focused advanced technology transition demos
- Restore stability to the technology base
- Provide top-down guidance to create an atmosphere that fosters technologies initiative; pursue novel, promising opportunities

Figure IV-1. Army Technology Base Investment Strategy

ALLOCATION OF RESOURCES

The TBIS provides the basic guidance for resource allocation. Implementation of the TBIS requires balanced partitioning of the resources into four descriptive categories. Figure IV-2 lists each category's components. At the core of the Army technology base is the science base, 6.1 Basic Research. Note that the science base supports all domains, just as 6.1 research can be in support of any of the domains. Although each domain may receive funds from any of the three funding categories, the investment in emerging technologies will be primarily from the 6.1 and 6.2 categories, and the investment in next-generation systems will be largely from 6.2 and 6.3A. Based upon the best judgment of the Army technology base leadership, the percentages shown represent the distribution of funds deemed appropriate for each of the four domains.

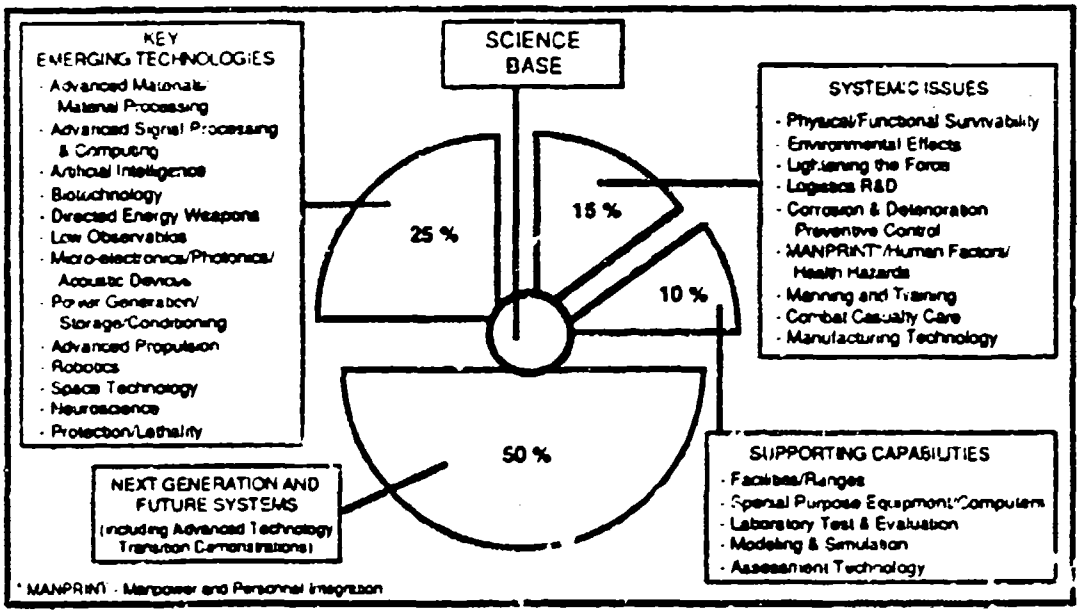


Figure IV-2. Technology Base Descriptive Categories and Resource Allocation Goals

THE SCIENCE BASE

The Army's 6.1 science base is the knowledge foundation for the 6.2-6.3A portion of the technology base. By identifying the vital areas in which scientific advances will be necessary to achieve the Army's vision of its future, this section discusses the direction of future medical research.

For a variety of reasons, the Army needs its own research program. First, Army-supported research acts as a window on academic and industrial science: it monitors scientific research and adapts advances to military needs. Second, 6.1 resources provide the Army with the ability to advance science in areas in which other supporters of research have little interest. Finally, the Army's research program builds and sustains the necessary in-house scientific capability to more quickly and effectively transition the results of basic research into militarily useful applications. To obtain benefits, however, Army research requires a long-term commitment, stable funding, and the clear program focus that this plan outlines.

The objective of Army biomedical research is to develop products that are both tangible (e.g., drugs, vaccines, medical equipment) and intangible (e.g., information to support doctrine/training/operations and prevent technological surprise). The inherent complexity of the human organism requires that the biomedical knowledge base encompass a broad range of scientific and technological disciplines. It is critical that the Army maintain biomedical expertise in all pertinent disciplines to maximize the benefits of "technology push," while investing in areas of specific interest to the military medical community, "requirements pull."

Although basic biomedical research concentrates on studies designed to characterize the pathophysiological and behavioral consequences of militarily significant disease and injury and to identify critical sites and mechanisms of actions, 6.1 programs are designed to conceptualize and formulate potential solutions to technological deficiencies. Concepts for effective medical countermeasures are further evaluated in Exploratory Development (6.2).

Basic Research Thrusts

From the very broad, classical scientific disciplines and diverse application areas, the Army has targeted nine areas for basic research emphasis. Table IV-1 shows selected products or applications of these research thrusts, organized by Army research areas as reported to the OSD. Table IV-2 shows how these research thrusts contribute to fulfilling research needs in the key emerging technologies areas (which are highlighted in Figure IV-2).

Table IV-1. Army Research Thrusts by Research Area

ARMY RESEARCH THRUSTS	ARMY RESEARCH AREAS				
	LIFE SCIENCES	PHYSICAL SCIENCES	CHEMICAL SCIENCES	MATHEMATICAL SCIENCES	ENGINEERING SCIENCES
MATERIAL SCIENCE	Biodegradation Bio-materials	High performance materials	Novel polymers Surface chemistry Chemically reactive polymers	Life testing Robust statistics	Micromechanics Fracture mechanics Mechanics of composites
CHEMICAL/ BIOLOGICAL DEFENSE	Mechanisms of action Hazard risk criteria		Pretreatment/ Treatment Catalytic oxidation and hydrolysis	Applied analysis	Life support equipment
BIOTECHNOLOGY	Recombinant DNA	Materials science	Enzyme models	Genetic modeling	Vaccine production
OPTICS	Sensory perception Dynamic opsins pigments		Surface chemistry Photochemistry		Nondestructive testing Laser diagnostics
COMMUNICATIONS & INFORMATION PROCESSING	Neural networks Decision aids		Electrochemical phenomena Sensing processes		
SYSTEM DYNAMICS	Army system requirements MANPRINT		Environmental quality		
INFECTIOUS DISEASE & COMBAT CASUALTY CARE	Recombinant vaccines Multi antigenic vaccines Neuroimmunology Computer aided [illegible]	Radiation/laser protection	Chemoprophylaxis Antimicrobial repellents Drug therapy Antibiotic micro encapsulation	Auditory modeling Casualty modeling & epidemiology	Life support equipment & diagnostic imaging Computer modeling of traumatic [illegible]
[illegible] PERFORMANCE	Materials Sensory perception Enhanced human performance Sensors		Performance in CBD environment	Artificial intelligence Decision aids Planning aids	
ATMOSPHERIC [illegible] & SPACE SCIENCE	Novel foods Remote [illegible]		Environmental [illegible]		

Table IV-2. Army Research Thrusts by Key Emerging Technologies

ARMY RESEARCH THRUSTS	KEY EMERGING TECHNOLOGIES					
	AI & ROBOTICS	MICRO-ELECTRONICS/ PHOTONICS/ SIGNAL PROCESSING/ COMPUTERS	ADVANCED MATERIALS/ LOW OBSERVABLES/ PROTECTION/ LETHALITY	DEW & POWER GENERATION	BIOTECHNOLOGY & NEUROSCIENCES	SPACE
MATERIAL SCIENCE				Magnetic materials	Bio-materials Biogenetic engineering	
CHEMICAL/ BIOLOGICAL OFFENSE	Decontaminants		Bio-materials	Micro-climate cooling	Enzyme models Biosensors Structure of macromolecules Monoclonal antibody	
BIOTECHNOLOGY	Sensory receptors		Bio-materials			Environmental controls
OPTICS		Image & signal processing	Laser protection		Visual perception	
COMMUNICATIONS & INFORMATION PROCESSING	Satellite sensing of climate	Casualty identification and processing			Neural nets Molecular modeling	
SYSTEM DYNAMICS		Network integration Software/Hardware modulation	Lightweight structure dynamics Elastomers		Enzymatic systems	
INFECTIOUS DISEASE & COMBAT CASUALTY CARE	Diagnostic technology & decision aids	Diagnostic imaging	Prosthetics Resuscitation fluids	EMP protection	Targeted drugs Vectored vaccines	Drug manufacture Geo-epidemiology
SOLDIER PERFORMANCE	Decision aids Reasoning under uncertainty Knowledge representations		Protective materials		Actovation Night vision Stress reduction Cognitive processing System Hazards	Motion sickness
ATMOSPHERIC TERRAIN & SPACE SCIENCE			High-temperature environments		Specialized chemicals & materials Altitude sickness	

Most of the research thrusts have application to medical science. Six are particularly relevant to USAMRDC programs: chemical/biological defense, biotechnology, communications and information processing, infectious disease and combat casualty care, soldier performance, and system dynamics. The relevance of these thrusts to Army needs and plans for these research areas are described below.

Chemical-Biological Defense. Medical research in this area focuses on the prevention, diagnosis, and treatment of chemical and biological warfare casualties. Medical biological defense research focuses on pathogenesis and physiology of toxins, endogenous physiologically active compounds, and other medical agents of biological origin as well as vector-control technology. Medical chemical defense research

will emphasize pathophysiological and biochemical studies to identify the effects of an expanding array of CW agents. Additional research relates to pharmacological studies of chemical biological (CB) agent absorption, distribution, and metabolism, to determine strategies for protection of soldiers against CB agents and treatment of CB casualties.

Biotechnology. To realize the potential of biotechnology for application in medical products, the Army needs to expand its knowledge base with regard to: the nature of macromolecular interactions; structure-function relationships; and enzyme active sites and membrane receptors. Other basic research supports the development of rapid identification and diagnostic methods for the assay of toxins, metabolites, and analogues in clinical specimens and collector samples. Studies include the investigation and evaluation of sensitive, specific methods of detection for both antigen and antibody in biological materials, cellular repair/regeneration, and the application of nucleic acid probes or synthetic antigens.

Communications and Information Processing. Research into artificial intelligence (AI) has contributed significantly to the development of expert system technology. Subjects of interest for application within the medical community include computer-based reasoning, perception, decision aiding, neural networks, and natural language processing. Research in this area is driven by new computer architectures and concepts related to the eventual implementation of AI, as well as by the increased knowledge of human brain function provided by research in the neurosciences. These concepts have wide applications in diagnostics and as aids for field decisions. Molecular modeling techniques are making important contributions to the development of prophylaxes and treatments for chemical and biological agent effects as well as to other aspects of military medicine.

Infectious Disease and Combat Casualty Care. Research targeted to the prevention and treatment of disease includes studies on the pathogenesis and immune mechanisms of rickettsial, enteric, parasitic, and other viral or bacterial diseases. Other studies concentrate on the modes of action of drugs, as well as on mechanisms of drug resistance and targeted drug-delivery systems. An important research focus is on development of generic medical countermeasures to broad classes of military disease threats.

Advances in combat casualty care are promoted by basic studies on the pathophysiological mechanisms, sequelae, and management of burns, shock, and combat-related trauma. Research focuses on identification of biocompatible and biodegradable materials for use as implants to replace lost tissues or bone; on resuscitation techniques, including blood technology and blood substitutes; and on ventilation. Of special importance are studies delineating the physiological and psychological tolerance of soldiers in climatic and environmental extremes, and studies on the effects of continuous operations and other combat-related stresses.

Soldier Performance. Medical research extends its focus beyond preventing and treating casualties to maintenance of soldier and unit performance in an increasingly complex and lethal environment. Environmental extremes, continuous operations, disrupted communications, protective clothing and equipment, complex equipment, sensory overload, and prophylactic medications for protection against infectious disease, BW and CW agents all add to the performance-impairing effects of anxiety. Research not only specifies the performance effects of these factors, but guides the development of second and third generation protection and battlefield treatments. Additional studies focus on enhancing soldier resiliency through individual stress management techniques, leadership strategies, doctrine and organization to optimize social support, and elimination of non-combat related sources of stress.

System Dynamics. The AMEDD has the responsibility to address the health hazards domain of MANPRINT for all system acquisitions. Modern technology tends to place operators and crews in dangerous operating environments. Blast overpressure, fumes, vibration, noise, and a host of other phenomena can have detrimental effects on crew and operator health. To fulfill MANPRINT requirements, research to develop an understanding of these effects must be supported.

Implementation

The USAMRDC implements these thrusts through 6.1 research oriented to the four medical R&D program directorates (described in Section V): Military Disease Hazards; Combat Casualty Care; Chemical Defense; and Army System Hazards. Table IV-3 illustrates which medical research areas address which research thrusts. Research investment is leveraged through research conducted by other Army and DoD agencies, industry, academia, and foreign sources.

Table IV-3. Basic Research Thrusts by Medical Research Programs

Army Basic Research Thrusts	Applicable Medical Research Programs			
	Military Disease Hazards	Combat Casualty Care	Army Systems Hazards	Medical Chemical Defense
Chemical/ Biological Defense	X		X	X
Biotechnology	X	X		X
Communication & Information Processing	X	X	X	X
System Dynamics			X	
Infectious Disease and Combat Casualty Care	X	X	X	
Soldier Performance	X	X	X	X

EMERGING TECHNOLOGIES

The Army has identified 13 technology areas as likely to have greater impact on future warfighting capabilities than would competing technologies. These are identified as the Army's key emerging technologies and are listed in Figure IV-2. Many of these technologies at least are indirectly related to the medical mission. Several hold near-certain promise of enhancing medical capability: neuroscience, biotechnology, and computing/artificial intelligence. The primary investment of the medical R&D community will be in the biotechnology and neuroscience fields; other technologies will, to a great extent, be exploited by the USAMRDC. Table IV-2 lists potential medical application areas of these technologies, by Army research thrust. Figure IV-3 depicts these technologies and the investment of more than $40 million a year that the medical community will invest in them.

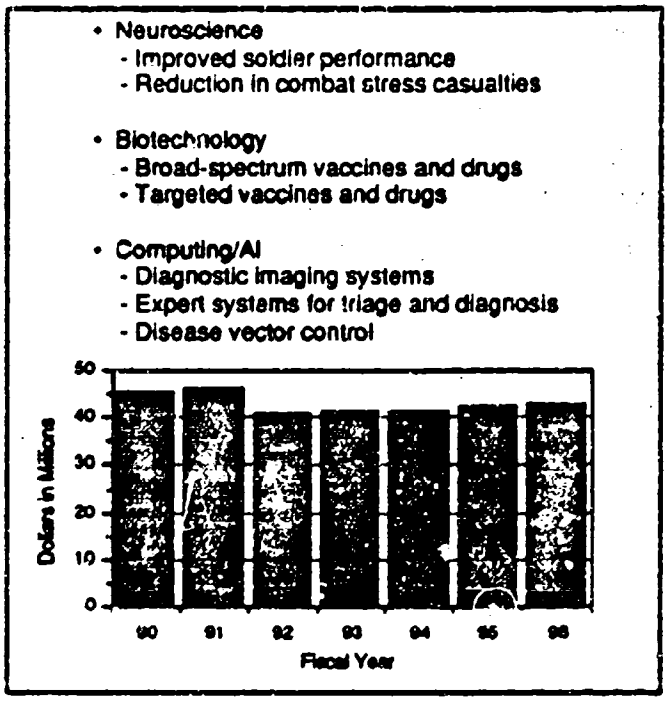


Figure IV-3. The USAMRDC Investment in Emerging Technologies

Neuroscience Technology

Neuroscience technology is an integration of many subdisciplines that share a common focus: the nervous system and its control of other biological systems. Within these subdisciplines, the Army addresses military-specific problems associated with sleep disruption, combat stress, cognitive and sustained performance, protection against chemical and biological weapons, casualty care and return-to-duty, and protection against infectious disease (Figure IV-4). Products of these research efforts will increase warfighting capabilities by protecting and sustaining the soldier--the most essential and often most vulnerable component of any Army system--while enhancing his performance.

The promise of neuroscience for the solution of Army problems is rooted in technical achievements that have made the discovery of detailed brain processes possible. Over the past two decades, the detection limits for brain modulators and membrane receptors--the sites for action by neurochemicals--have decreased exponentially (Figure IV-5). Assay specificity in detecting minute differences between brain substances has also dramatically improved. These advances have led to the discovery of additional neuromodulators--the regulators of biological systems--and to an understanding of their responses to environmental disturbances. Transformed into rapid, precise analytic test methods, these discoveries have spawned new pharmaceuticals, the effects of which can now be studied via test-tube analyses of brain receptors and cultured brain tissue, and by computerized quantitative structure-activity relationships. In parallel, breakthroughs in brain-imaging techniques--computerized tomography, magnetic resonance imaging, and positron emission tomography--have permitted noninvasive, real-time views of both structure and function. These leaps in measurement technology have revolutionized the time resolution of measurements, abbreviated the data collection process, and increased the rate of discovery.

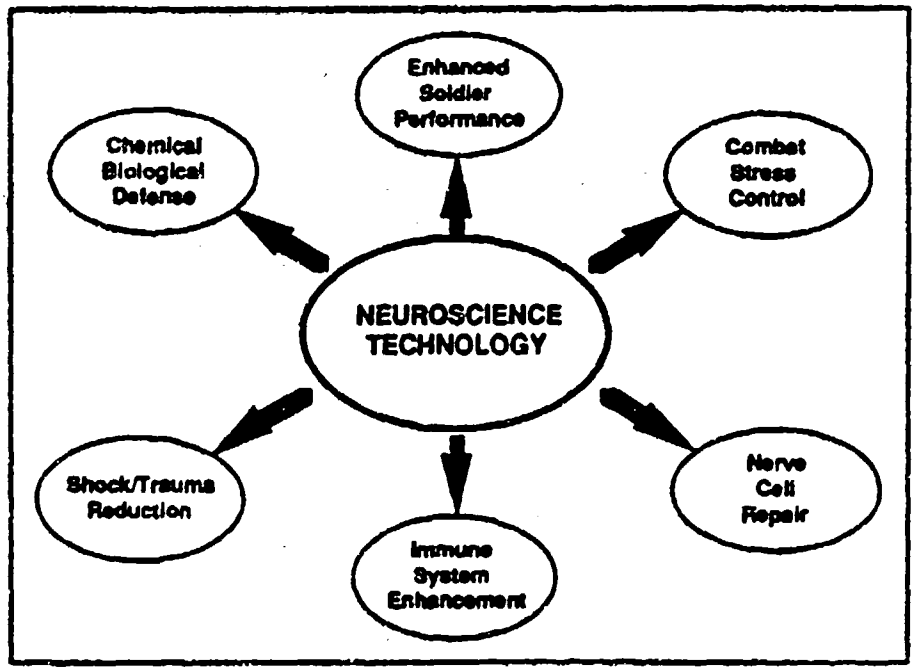


Figure IV-4. Neuroscience Contributions to the Warfighting Mission

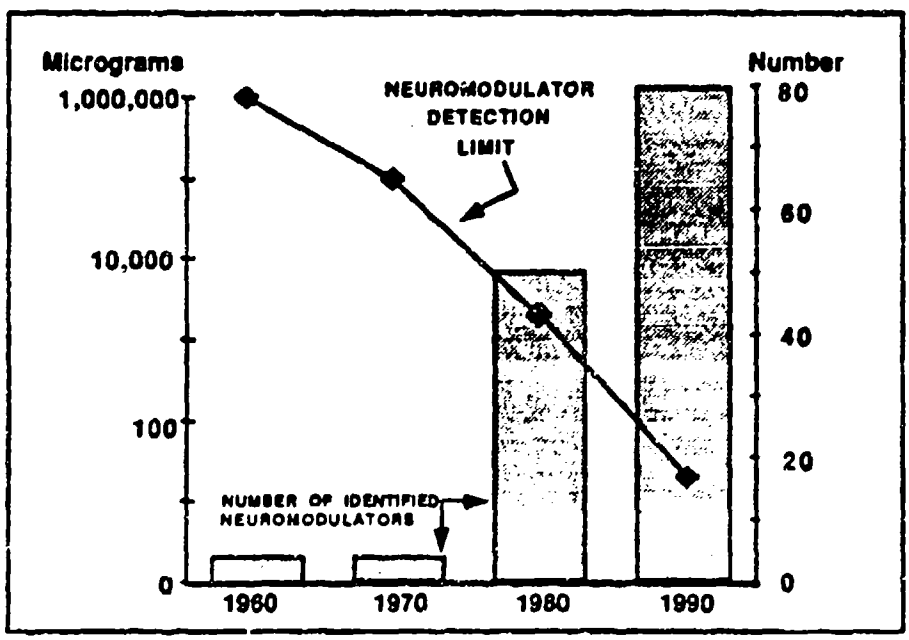


Figure IV-5. Advances in Neuroscience Technology: Number of Identified Neuromodulators Increases as Detection Limits Decrease

Neuroscience may provide the ability to optimize military performance under stressful conditions of modern and future combat operations. The historical trend in engagements is a steady escalation in the number of attacks per day. The advent of night-vision devices and the prospect of facing an enemy with superior numbers dictate that future conflicts be waged continuously. Soldiers and their leaders will have to remain alert for days, with little or no sleep. Brain-image analysis of local changes during sleep disruption and neurochemical assays during sleep will suggest new ways to prevent the usual performance degradations that occur during sleep disruption, and to improve the restorative powers of limited sleep.

The greater intensity and lethality of the future battlefield will exacerbate combat stress. Nearly 30 percent of the casualties in a high-intensity war will be psychiatric, an increase caused by more combat stress breakdown--a military-specific syndrome that can render normal soldiers temporarily ineffective when they are exposed to the extremes of battle. Neuroscientific advances during the 1980s have provided a detailed picture of the neurochemical changes that accompany severe stress reactions. By exploring the detailed mechanisms of stress--progressive changes in the brain coupled with specific precipitating events, culminating in breakdown--concepts can be developed to protect the soldier from battlefield stress's most debilitating aspects without distorting his appropriate assessment of risk (see Figure IV-6). Clearly, the control of combat stress and the rapid return-to-duty of stress casualties are essential combat multipliers.

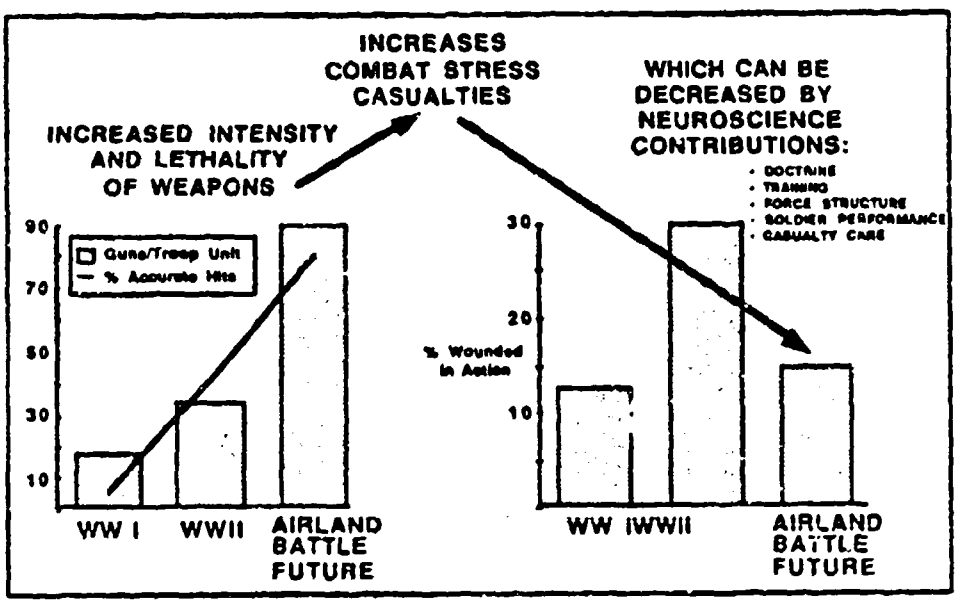


Figure IV-6. Neuroscience Technology Contribution to Reduction in Combat Stress Casualties

Already, neuroscientific technology has advanced the development of pretreatments and of second-generation antidotes for nerve agents. During the next decade, emphasis will be on pretreatments against and antidotes for future chemical and biological threat agents (Figure IV-7). These new compounds will be more efficacious and specific, and will produce fewer side effects. Their use during a threat agent attack will reduce the number of incapacitated soldiers, severity of the agent's effects on survivors, and the number of deaths. It is expected that their development will deter the use of chemical and biological weapons.

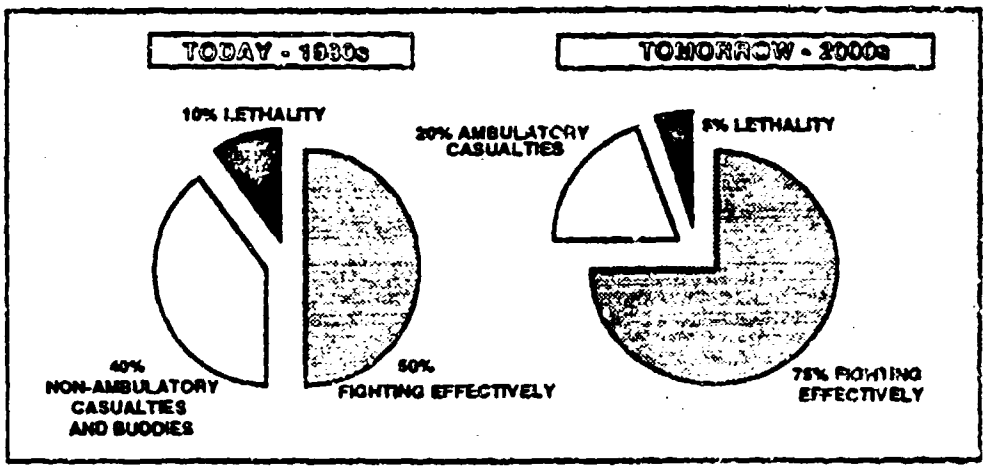


Figure IV-7. Biotechnology and Neuroscience Contribution to Protecting the Fighting Force From CW/BW Threats

The most sweeping advances in soldier protection and performance enhancement will build on recent neuroscientific discoveries: the existence of an intricate web of relationships between the brain and other biological systems, and the identification of specific neuromodulators that control an array of processes. For example, one substance released from the brain after severe blood loss triggers shock--a lethal reaction when untreated, and a major cause of battlefield death. Chemical blockers can reverse this state in seconds; administering them allows a soldier to survive until more definitive care can be provided. A similar, experimental approach has been used to prevent the death of nerve cells following trauma to the spine, thus protecting against paralysis. Another area of investigation involves the roles that other brain substances play in modulating the body's immune system, especially during periods of stress. This area promises to provide an additional means of protecting the soldier from infectious disease, the primary cause of personnel losses in all wars.

Biotechnology

Biotechnology comprises a variety of techniques for manipulating and controlling biological processes. The DoD defines it as "any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants, or to develop microorganisms for specific uses. The technologies specifically included in this definition are recombinant DNA, cell fusion technology including hybridomas, somatic cell genetics, and novel bioprocess techniques." Although biotechnology offers the potential for dramatic advancement in many areas of military interest, its greatest potential is in military medical defense and health services. Industry, as well as the military, is exploiting advances in biotechnology. The examples that follow highlight biotechnology's potential for solving military medical problems. Numerous other military applications of biotechnology exist in areas such as detection, identification, and decontamination of chemical and biological agents and in a whole range of products from the field of materials science. Research in biotechnology is not only a medical defense goal: it is a national imperative.

Endemic disease and biological threats can pose barriers to deployment and warfighting. It is expected that research in molecular biology will lead to medical prophylaxes and treatments that offer improved specificity and potency, thus increasing efficacy and reducing side effects. Figure IV-8 demonstrates the predicted effect of the application of biotechnology to medical defense on the time

required to counter disease threats. The development of multivalent vaccines that confer immunity against more than one disease will be emphasized in the near term. These vaccines will simplify the medical logistics system and will minimize the likelihood of surprise by either Nature or hostile action. The new generation of medical prophylaxes and treatments made possible by biotechnology promises to facilitate deployment to areas of the world in which endemic diseases or biological agents would now threaten the success of military operations, and to greatly reduce the adverse impact that disease has had on the availability of troops for combat and training.

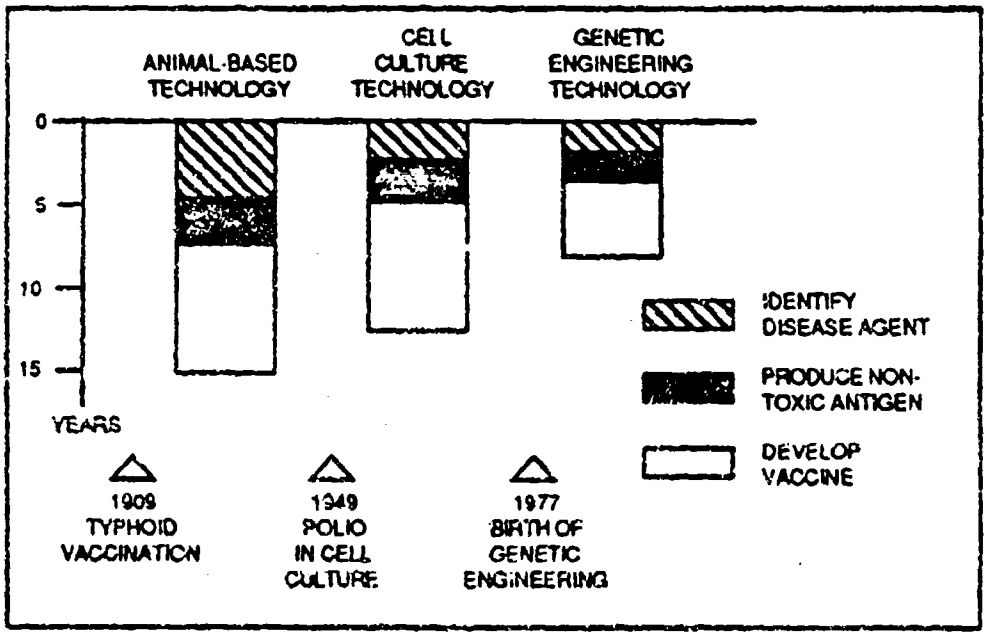


Figure IV-8. Biotechnology: Reduction in the Time Required to Counter Disease Threats

Medical biological and chemical defenses are other areas in which biotechnology offers the potential for dramatic increases in defensive capability. The spectrum of currently recognized toxins and chemical threats represent one of the major warstoppers we may face on the battlefield today, and biotechnology will provide our adversaries with an increased capability to field chemical agents and toxin weapons. We must use the potential capability of biotechnology to defend against these threats. Knowledge of the agents is critical to preparing our defense. Biotechnology can provide the capability to diagnose or analyze a wide variety of parameters critical to defense, from the nature or identity of the agent to the blood chemistries of casualties. More importantly, biotechnology can provide the prophylaxes, antidotes, and treatments to counter the threats.

Progress is underway in designing and testing biotechnology-produced products for nerve agent prophylaxis. As shown in Figure IV-7, products of biotechnology, in conjunction with neuroscientific technology, will allow a much larger fraction of soldiers to stand and fight after having been exposed to chemical or toxin agents, reduce the degree of incapacitation of low-dose casualties, and shorten return-to-duty times. By enabling a larger percentage of casualties to treat and evacuate themselves, these products will significantly decrease the combat manpower burden imposed by "buddy aid," and extended loss of duty.

In addition to reducing disease and providing chemical and toxin defense, biotechnology may enhance soldier performance in other ways, including improved nutrition and other advances in soldier sustainment not yet conceived. Potential battlefield payoffs include increased tolerance for stress induced by fatigue and by extremes of heat and cold. Other medical defense payoffs can derive from rapid wound repair, synthetic blood replacements, and bone healing -- all of which will extend the ability to support extended field operations and improve soldier survivability. Also, the cost of many medical and organic products will be greatly reduced as biotechnological synthesis becomes feasible.

Over a longer time frame, concepts under study are expected to lead to techniques for organ and nerve regeneration, and to a battlefield role for medical interventions that today are classified as "heroic" measures. These advances would reduce the number of casualties, speed recovery of casualties, and hasten return-to-duty, thereby reducing manpower and logistics requirements of future battlefields. Biotechnology will be a major force multiplier of future warfighting capability.

Computing/Artificial Intelligence

It is well recognized that integration of new computer technology has had a dramatic effect on almost every aspect of the Army's warfighting capability, as well as on how that capability is exercised. The capability to deliver medical care on the battlefield should be no exception. Advances in computation will not only provide new tools and products for the field, but also will enable advances in other emerging technologies through laboratory applications. Although the USAMRDC will not be a major investor in the development of computing and related software technology, exploitation of this technology for both laboratory and field applications will be an essential component of the medical TBIS.

One of the most immediate applications for high-speed computers and expert systems will be in improved diagnostics. It is expected that current technological capabilities in applications such as blood cell counting, microscopic urine examination, and other pathology determinations will be extended. Computer-enhanced diagnostic imaging in X-ray applications is currently being explored by the USAMRDC. Future applications should see increased use of expert system software for automated recognition of normal and abnormal structures as well as computer-assisted diagnoses and recommendations of treatment alternatives.

Triage on the battlefield is another process that could benefit from application of computer and software advancements. The requisite diagnostic and resource management skills of casualty care are extended to their limits in mass casualty situations. The use of computer-assisted diagnosis, expert systems, and simplified computer interface design would enhance the capability of physicians and physician extenders to provide timely and productive medical care on the high-intensity battlefield, to a single casualty or to many.

SYSTEMIC ISSUES

Systemic issues are pervasive and persistent problems that may not have a system focus, but are critically important to success on the battlefield. It is essential that the Army aggressively pursue solutions to such problems, because even partial answers have the potential to provide major advances in our warfighting capabilities as well as return savings in the form of reduced operating and health care costs. By any measure, such solutions invariably have an extremely high return on investment.

Ten issues are listed in the ATBMP. They are: atmospheric/environmental effects; lightening the force; logistics research and development; reliability, availability and maintainability (RAM); fuels and lubricants; corrosion; soldier-oriented research and development; manufacturing technology; construction technology; and battlefield software engineering and support. The medical technology base contributes in the area of Soldier-Oriented Research and Development (SORD). SORD is the Army's

overall initiative to ensure that state-of-the-art technology is developed and applied for the soldier, from enlistment to performance and survival on the battlefield. SORD comprises three areas: Personnel and Training, MANPRINT, and Health Services. The medical technology base contributes to the Health Hazards domain of MANPRINT as well as to Health Services. Figure IV-9 lists the major issues under study and reflects the sustained resource commitment to this area, ranging from more than $30 million in 1990 to more than $40 million in 1996.

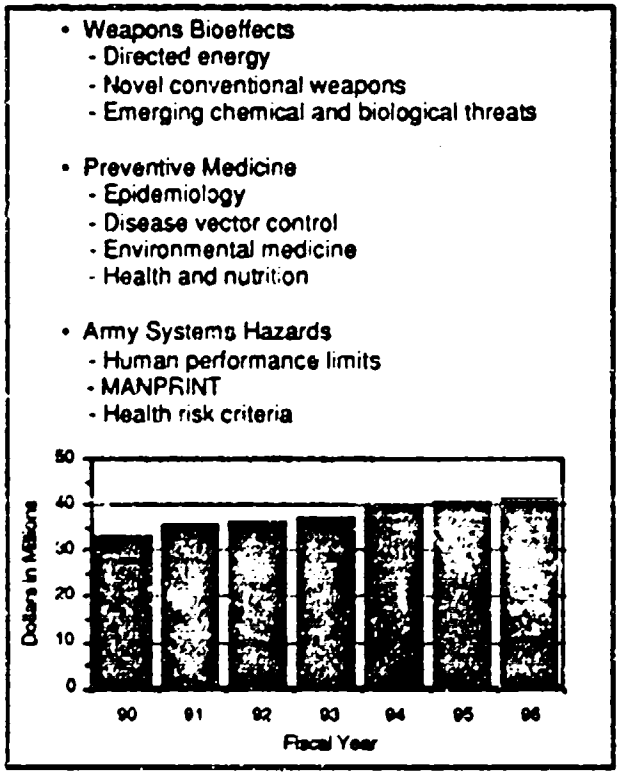


Figure IV-9. The USAMRDC Investment in Systemic Issues

Health Hazards Domain of MANPRINT

Taking the soldier into account as operator, user, and/or maintainer when designing a weapons system continues to be a persistent research and design problem. What is known about soldiers' capabilities must be integrated into system design from the beginning. Technological advances can be negated if soldier-oriented issues of maintainability, training, soldier availability, health hazards, and crew performance are not addressed early in system design. The MANPRINT process (AR 602-2) is the Army's initiative to ensure that these factors are considered.

Future Army systems will continue to challenge the physiological and psychological tolerance limits of the soldier operator through exposure to such occupational hazards as: toxic fumes, vibration, noise, and impulse overpressures from operation of our own weapons systems or from nonpenetrating impacts on combat vehicles; non-ionizing electromagnetic radiation from laser rangefinders and target designators; and microwave/millimeter wave emissions from communications and radar systems. These hazards present significant, but manageable, risks for health and performance degradation.

As our own forces modernize their weapons systems and tactical operations, medical research must maintain a technology base to identify potential deficits in the planned use of the soldier himself, or in the interaction of the soldier with Army systems. Research efforts will generate the knowledge base necessary to: define the limits of human physiological and psychological tolerance; identify the health risks in the evolving battlefield environment; develop the risk assessment methodology required to evaluate the hazards; recommend the criteria for design of the protective equipment necessary to eliminate or reduce risks to health and performance; and, finally, to establish methodologies to evaluate effectiveness of current and new integrated protective equipment systems.

The failure of the system designer to adequately consider the capabilities and limitations of the operator is a chronic problem in materiel design. Identification of the demands on and risks to the soldier operator during the development of concepts allows time for assessing the nature and magnitude of the problems, and ensures fielding of a hardware system whose performance is not unnecessarily constrained by the physiological/psychological capabilities and tolerance of the operators. It is essential that hazards affecting human operators be considered early in the development cycle. Post-production modification to correct operator-related system deficiencies is, at best, expensive, and, at worst, impossible.

Health Services

Health services consist of those services performed, provided, or arranged that promote, improve, conserve, or restore the mental or physical well-being of individuals or groups. Although all medical research and the investments in each of the domains of the TBIS support health services, several research issues require continuing attention and are thus part of the Systemic Issues domain. These issues can be grouped under the broad headings of Preventive Medicine, Combat Casualty Care and Survivability/Sustainability.

Preventive Medicine. Disease, not injury, can be expected to remain the major contributor to manpower loss during wartime. Although it is planned that drugs and vaccines will be developed to compensate for the lack of natural immunity for diseases not endemic to the U.S., such gains may be reversed by disease organisms' constant evolution of drug-resistant strains. Medical technology base research will continue to emphasize fundamental studies to prevent, diagnose, and treat infectious diseases and biological threat agents that endanger the ability of U.S. Forces to deploy and sustain operations in any part of the world. Continuing attention must be paid to the issues of vector transmission and control, epidemiology, and risk assessment to prevent threat surprise.

Combat Casualty Care. The increasing complexity and intensity of the future battlefield will present persistent challenges to the AMEDD's efforts to sustain warfighting capability in accord with its mission to conserve the fighting strength. The nature and weapons of warfare are constantly evolving and the Army will continue to need a combat casualty care research program that supports the warfighting capability through enhanced return-to-duty rates in the forward battle area for soldiers who have sustained non-life-threatening wounds or injuries and a reduction in the morbidity and mortality from battlefield episodes of major physical or psychological trauma. Combat casualty care must adapt to the high-intensity, integrated battlefield to provide resuscitation, treatment, and return-to-duty capabilities to smaller units operating far forward with limited logistical support. Medical capabilities must provide effective diagnostics and treatment for single and combined injuries expected from future weapon systems employed on the integrated battlefield.

Survivability/Sustainability. The psychological and physiological stressors of the military environment are not restricted to systems covered by MANPRINT, disease, or wounds. The age old problems of operations in terrestrial and climatic extremes and the mental stress of combat remain, and in some cases will increase in importance, in the era of AirLand Battle-Future. Biomedical research into the capabilities and limitations of the soldier will continue to be important in ensuring both improved survivability and sustainability of the human component of warfighting systems.

SUPPORTING CAPABILITIES

Supporting capabilities are those elements of the R&D program that abet the technology development process: facilities in the Continental United States and overseas; special-purpose equipment and computers; testing technology; simulation and modeling resources; and assessment technology. These provide the structure and the tools with which the R&D community can achieve the required Army systems of the future.

The Army must maintain a robust and forward-looking R&D establishment of world-class stature if it is to attract and retain the high-quality personnel who will develop the winning technology of the future. Recent experience indicates that inadequate, antiquated facilities and equipment are key factors in the departure of many of our most productive scientists. If this trend is to be reversed, a concerted effort must be undertaken to place greater management emphasis on supporting capabilities.

Figure IV-10 depicts priority supporting capability requirements for the medical technology development community and the budget of approximately $20 million per year. These funds come from the Army technology base budget. Other support funds are obtained. For example, physical plant and range costs are generally secured through MCA funding in a separate Congressional appropriation. R&D competes with other Army and DoD activities for the MCA appropriation. Technology base support capability funds can also be provided through: Operations and Maintenance, Army (OMA); technology management (6.5/6.7); and advanced and engineering development (6.3B/6.4) appropriations, particularly when the monies are for special-purpose equipment, test and evaluation facilities, and computers. Usually, however, this benefit takes the form of acquiring equipment left over from these activities for technology base application.

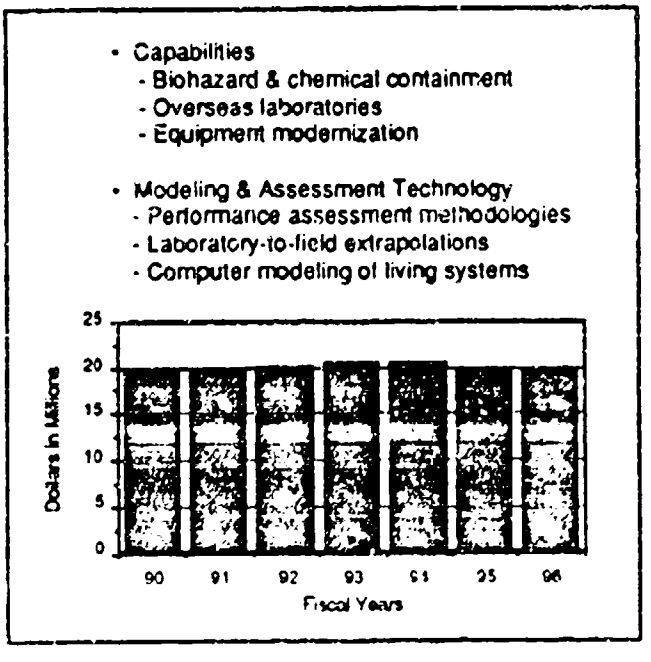


Figure IV-10. The USAMRDC Investment in Supporting Capabilities

Equipment and Facilities

Although technology base funds normally are not used for facilities construction, they are often used for the laboratory renovations and new equipment necessary to support specific projects. The age of current facilities, the space and utility demands placed on these facilities by modern research equipment and the requirements imposed by Federal regulations governing animal care, occupational health and safety, and environmental protection, have placed an increasing burden on both technology base and other funds used to support facilities [e.g., MCA, Real Property Maintenance Activity (RPMA)].

Many facility renovation needs are handled locally through the use of current year funding, often to the detriment of ongoing technology base programs and at a sub-optimal level of effort, in order to stay within local expenditure authority. An integrated, Army-wide effort must be initiated to optimize renovation projects of critical importance to the R&D mission and secure activity-wide funding authority on an annual basis for these small but important projects. The OASA(RDA) is exploring solutions to these problems, but each laboratory must continue to carefully balance, within allocated resources, the investment requirements of R&D and its supporting infrastructure.

The Army's technology base R&D community is housed in buildings that average 31 years of age. The CONUS laboratories of the USAMRDC are even older, an average of 40 years. Over $200 million in MCA requirements currently exists for medical R&D facilities. Primary needs include replacement of the Walter Reed Army Institute of Research and expansion for the U.S. Army Medical Research Institute of Infectious Disease (USAMRIID). Additional requirements depend on Congressional decisions concerning implementation of the findings of the Base Realignment and Closure Commission, which recommended the relocation of the Letterman Army Institute of Research (LAIR) to Fort Detrick, Maryland.

Modeling and Assessment Technology

The use of simulations and computer models represents one of the greatest potentials for advancing the Army's R&D program effectiveness. The overall objective of this effort is to change the development process from one of "prototype-build-test-break-fix" to "simulation-based man/hardware-in-the-loop." In many cases, this will permit: evaluation of advanced concepts before prototype construction, lower developmental costs, elimination of false starts, and shorter developmental timelines. This area can be divided into two general categories: physical simulation and analytical simulation.

Physical Simulation. In numerous areas, physical simulation is a vital element toward better understanding the problems facing the soldier on the battlefield and their potential solutions. Physical simulation models provide data for situations in which the risk involved precludes use of humans or in which the cost of field testing is prohibitive.

Medical models in this category include cell- or animal-based models used to identify physiological sites and mechanisms of action of health threats, and to evaluate/predict the effectiveness of candidate medical countermeasures to these threats. The unique nature of many military health threats (e.g., biological weapons, diseases rare to the U.S.) mandates continual attention to model development. Additionally, expectations of continuing social and political sensitivity to the use of animals in research demand an increased investment in research aimed at reducing the medical community's dependence on animal models.

Medical research also requires hardware-type simulators, such as environmental chambers and aircraft simulators, to meet mission responsibilities economically. These simulators enable detailed study of operations in controlled stressful environments.

Analytical Simulation. Analytical simulation techniques provide the methodology for generalization and extrapolation of effects from a limited base of experience or data and provide insight into the real-world implications of military/medical operations.

More effectively extrapolating the results of animal experimentation to man, and of human research from the laboratory to the field setting, presents a continuing challenge for science. The development of more accurate and reliable assessment and prediction models and techniques will facilitate the utilization of basic research results; reduce the time required to field improvements in materiel, doctrine, and training; and reduce research costs.

Further research on hazard risk analysis will be required to more closely match this methodology to the unique requirements of the military environment. Techniques that are adequate for the civilian workplace may be unsuitable for the military, especially under wartime conditions. This situation magnifies the long-standing problems that operational planners have had in estimating individual and unit performance decrements associated with operations in NBC-contaminated environments. A better understanding of the physiological effects of various exposure to NBC threats, coupled with the predictive methodology necessary to translate these effects into operational impacts, will allow commanders to select the minimum level of protective posture required to accomplish a mission.

Finally, analytic modeling assists R&D program planners in efficiently allocating scarce resources among competing requirements. Examples of this type of analysis can be found in Section II (i.e., AURA modeling).

NEXT-GENERATION AND FUTURE SYSTEMS

The ultimate mission of the Army's technology base program is to provide the soldier with a fighting advantage on the battlefield. To this end, the Army identifies promising technologies, then executes basic and applied research that examines them, advancing the state of the art as necessary toward the application of these technologies to militarily significant problems.

A major responsibility is to show that the technology is mature enough to be incorporated into a system that will be fielded. Technology demonstrations (discussed below) are one link between today's technology development and tomorrow's systems.

Army modernization plans are developed as a coordinated effort of technologists, system designers, and users. The R&D community defines the capabilities that new technologies make possible; the planners fit these capabilities into the Army's plans for systems. It is an iterative process in which the Army modernization plans and the TBMP reinforce each other through dialogue among the players.

Advanced Technology Transition Demonstrations

To more expeditiously incorporate emerging technologies into fielded systems, the 1987 Defense Science Board Summer Study on Management of the Technology Base recommended a new class of technology demonstrations, the Advanced Technology Transition Demonstration (ATTD). Successful ATTDs are candidates for direct transition to Full-Scale Engineering Development (6.4), bypassing both the Concept Exploration and Demonstration/Validation phases of 6.3B. Defined as technology demonstrations lasting approximately 3 years, costing $10 million to $100 million, and conducted in a field environment with participation by the CBTDEV (i.e., with troops), ATTDs will comprise 50 percent of the total 6.3A program by 1991, according to OSD direction. The programs will be reviewed and fenced by both the OSD and the JCS. A list of ATTD criteria is shown in Figure IV-11.

- Risk-reducing "Proof of Principle" demonstrations to be conducted at the system or major subsystem level in an operational environment rather than in the laboratory environment.
- Potential for new or enhanced military operational capability or for significant improvement in cost effectiveness.
- Duration of 3 years (typically).
- Total program cost of $10 million to $100 million (typically).
- A transition plan in place at the outset of the ATTD. Potential systems applications and transition windows should be identified at this time.
- Participation by the user (operator). Ordinarily, the user should serve as the program sponsor.
- Participation by the developer (systems command). The developer should serve as project manager for the demonstration.

Figure IV-11. Characteristics of ATTD Projects

Medical Technology Demonstrations

The USAMRDC's 6.3A research programs do not meet the formal definition of an ATTD. As required by Federal law, it is established DoD and Army policy that all biologicals, pharmaceuticals, and other medical materiel subject to Federal regulation be approved by the FDA prior to purchase or use by U.S. military forces. The FDA regulations permit human testing only after extensive preclinical tests have demonstrated the safety and efficacy of the products in technology demonstrations using nonhuman models. As discussed in Section I, medical 6.3A programs (i.e., Core Drug and Vaccine Program) are designed to provide the preclinical data base which is used both to gain FDA approval for human testing and as the basis for a Milestone 0 decision. It is human safety and efficacy, not the formal process of the Army's system of life-cycle management, that is rate-limiting in the development of medical products.

The operational environment of medical 6.3A technology demonstrations involving unlicensed drugs and vaccines is restricted to laboratory testing in nonhuman models by FDA regulations, as well as DoD policy. Even after FDA approval is obtained, in many cases human testing cannot be conducted in a truly operational environment due to legal, moral, and ethical proscriptions (e.g., exposing troops to BW or CW agents).

The approach to technology demonstration within the Core process is to use the diverse contractor and in-house capabilities provided by the Core Drug and Vaccine Program to produce the information required both to gain FDA approval for human testing and as the basis for informed decisions on the technical feasibility, field utility, and cost-effectiveness of candidate products. The process gains its cost effectiveness from management as individual technology demonstrations within a consolidated and sustained Core program (see Figure IV-12).

Given that vaccines and drugs already have the support of the CBTDEV and user (i.e., generic or CAPSTONE O&O plans have previously been approved), and that a well-developed system for assessing technological feasibility is in place, the preponderance of the medical 6.3A program already meets the intent of the Defense Science Board (DSB) which led to the current ATTD program emphasis. The user representatives understand the restrictions on medical R&D and support developmental new starts if modeling of operational conditions in a laboratory setting identifies a potentially successful candidate. The user community, through participation by representatives of the medical CBTDEV and the Surgeons General of the Services, takes part in the evaluation process through established decision and oversight forums such as the MSRC, the AMEDD Tech Committee, and the ASBREM Committee.

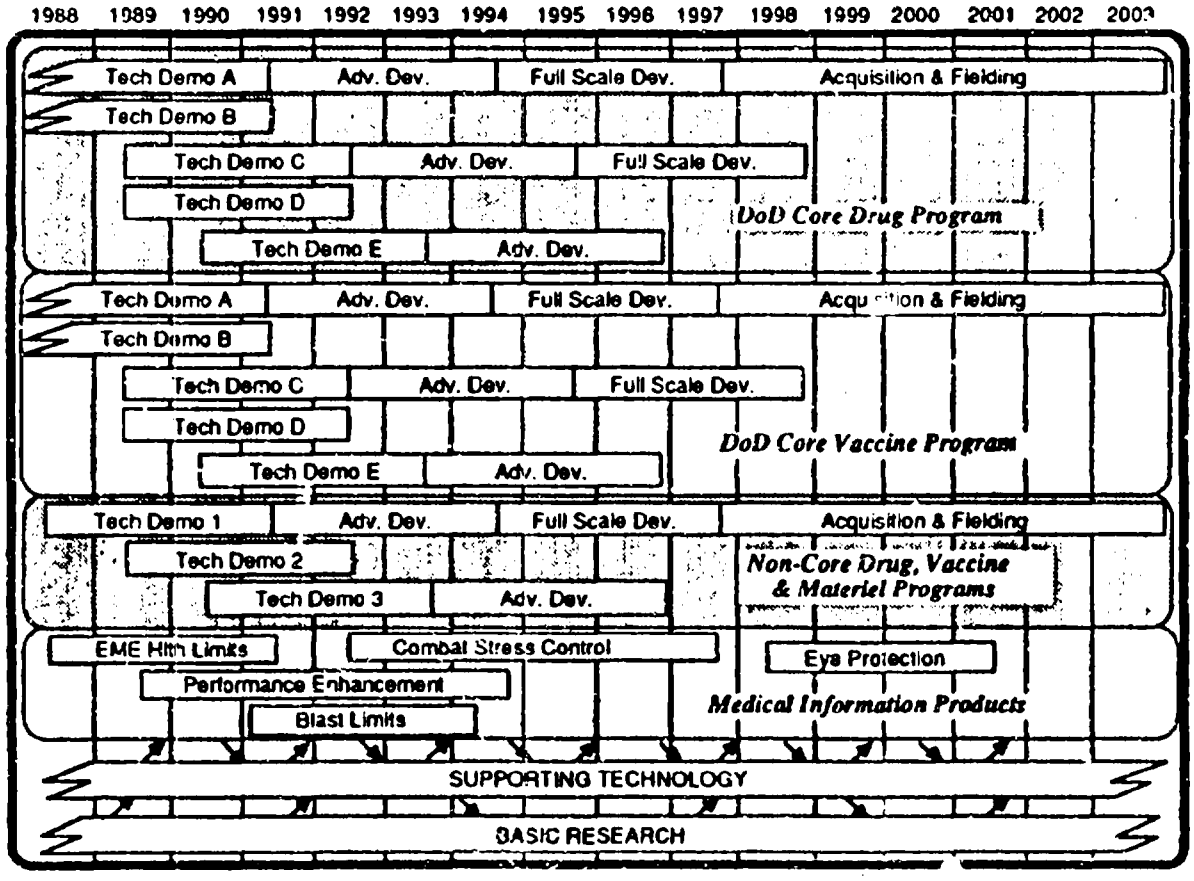


Figure IV-12. Medical 6.3A Program Technology Demonstration: Planning for Future Systems

In recognition of the inapplicability of the strict ATTD guidelines to medical 6.3A programs and the need to sustain the Core Drug and Vaccine program, the Deputy for Research and Technology, OASA(RDA), has agreed to consider the Core Program equivalent to ATTDs in terms of meeting DoD's mandate for a 50 percent investment.

Several work units within medical 6.3A projects do support other Army ATTDs, particularly the Soldier-Integrated Protective Ensemble (SIPE). Among medical efforts supporting SIPE are the Core Drug Program, which supports the technology demonstration for skin protectants; the laser bioeffects program, which supports laser eye protection; and the environmental and nutrition research programs, which support the development of combat rations tailored for environmental extremes. Technology demonstrations for medical equipment and validation of medical information products are also conducted within the 6.3A program.

Next-Generation and Future Medical Systems

To support the goals of The Surgeon General's Medical Modernization and Health Services Long-Range Plans, new generations of medical systems and products will be assessed for technical feasibility and operational utility. Primary emphasis will be placed on systems to support conservation of the warfighting capability through prevention of casualties and through increased return-to-duty rates for soldiers incapacitated by disease or injury.

Medical products for the soldier and combat health care provider are grouped into five families of systems: (1) system of medical defense against infectious diseases, (2) system of combat casualty care, (3) system of soldier protection, sustainment, and enhancement, (4) integrated system of medical chemical defense, and (5) integrated system of biological defense. Details concerning next-generation and future systems within these families are provided in Section VI. Figure IV-13 depicts the investment of more than $70 million a year that the USAMRDC will invest in these technologies. The following paragraphs describe the strategy for future investments in technology base research programs supporting advances in each of these families, key products within the family, and the expected benefits to military warfighting capability.

System of Medical Defense Against Infectious Diseases. The ability of U.S. Forces to deploy and sustain a warfighting capability anywhere in the world must be supported by the development of products for the prevention, diagnosis, and treatment of infectious diseases, especially those for which U.S. Forces have no natural immunity. New generations of vaccines and drugs will be required to counter those disease-causing organisms that have developed resistance to current medical countermeasures. First-generation medical countermeasures must be developed to diseases endemic to those areas of current and most probable future U.S. military involvement and to diseases for which there are no current vaccines. Product improvements in topical skin protectants for insect-borne and other parasitic diseases should also be pursued. A key product with high impact on manpower availability is a vaccine effective against malaria, a disease which has traditionally debilitated U.S. Forces deployed to tropical areas.

For future systems, increased application of the principles and techniques of biotechnology will facilitate the development of safer, more effective vaccines. Expanded use of genetic engineering technologies will advance the development of polyvalent vaccines, which can confer immunity to more than one disease. Biotechnology offers the capability to rapidly counter, or perhaps avoid, the development of resistant organisms. Additionally, application of microencapsulation and liposomal technology, coupled with knowledge gained from the neurosciences, will enhance prospects for the development of targeted drug and vaccine delivery, reducing the potential for performance debilitation and toxic side effects and allowing new approaches to disease prevention and treatment.

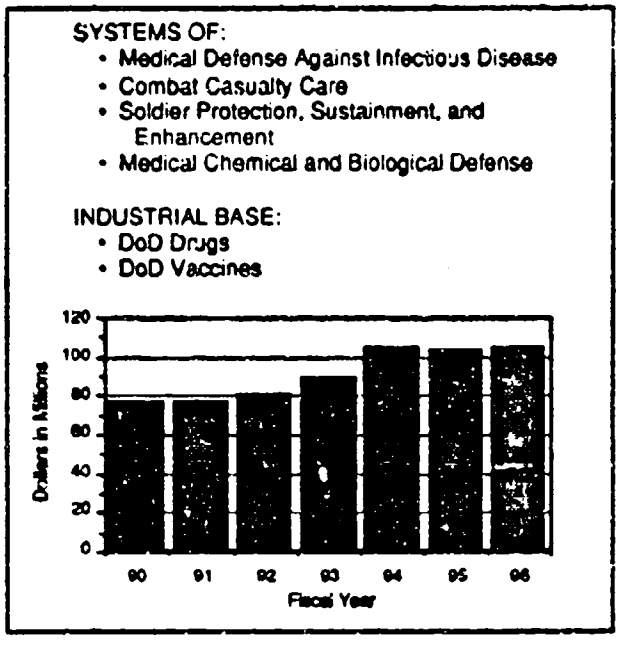


Figure IV-13. The USAMRDC Investment in Next-Generation and Future Systems

System of Combat Casualty Care Troops returning to duty from the health care delivery system provide operational forces with their primary source of trained and experienced replacements. Force effectiveness should be strengthened through concepts and materiel that foster enhanced return-to-duty rates in the forward battle area and that support reduced morbidity and mortality. The evaluation of medical materiel and techniques for combat casualty care should focus on the identification of improved diagnostic, resuscitation and stabilization techniques for employment far-forward. The primary goal is to provide a margin of safety against the delays in evacuation to definitive medical treatment facilities which can be expected on the integrated battlefield. Examples are: a therapeutic compound that would reduce the incidence of brain damage which often accompanies head injury, blood loss, or shock; blood substitutes; and miniaturized x-ray sources and filmless x-rays.

Since military medicine will continue to depend, in wartime, upon Reserve Component personnel, as well as on physicians recently trained in a civilian setting, it is important that the medical 6.3A program continue to provide a path for inserting current medical technology into future systems, materiel, and methods supportable in the field environment. Improvements in medical equipment will result from advancements in microelectronics, power generation/storage, advanced materials, computing, and artificial intelligence: for example, the availability of lightweight, field-portable, medical diagnostic systems using techniques such as magnetic resonance imaging (MRI).

Expert computerized systems for triage and diagnosis at the battalion aid station will reduce the requirement for professional medical training and will promote the expeditious handling of and appropriate treatment for combat casualties. Advances in the neurosciences will provide for improved return-to-duty of psychiatric casualties.

System of Soldier Protection, Sustainment, and Enhancement. In addition to the threat of disease or injuries as a direct result of enemy action, the nature of the military occupational environment itself

contains unique threats to the health and well-being of soldiers, in training as well as combat. The climatic and terrestrial environments in which soldiers must train, work, and fight expose them to increased risks of injury, illness, or performance degradation from extremes of heat, cold, and high terrestrial altitude. The systems they operate may present additional health hazards from electromagnetic or non-ionizing radiation (lasers, high energy microwaves, particle beams), noise, vibration, blast overpressure, and toxic chemical by-products of weapons system operation, including fire and explosion. Products in this system provide preventative or therapeutic countermeasures against these threats and also maximize soldier performance effectiveness during deployment and sustained operations. Although information products provide major contributions to this system as guidelines for Materiel Developers and hazard-risk criteria for use by Commanders, the resources allocated to information products are captured under the TBIS category of Systemic Issues (see p. 4-13 ff). Only those medical resources dedicated to development of materiel solutions are captured here. In some cases, the end item is developed as a non-medical product in coordination with the Army Materiel Command.

Next generation contributions of this system include biomedical health and performance assessment of two Army Materiel Command products: the Soldier-Integrated Protective Ensemble (SIPE) and a field feeding system. Medical items under development include two drugs which use neuroscience technology to improve soldier performance, i.e., for prevention of acute mountain sickness and for sleep induction to prevent jet lag during long deployments.

Future products in this area must keep pace with the hazards of future weapon systems as they are developed. Several biomedical approaches are under investigation for protection against laser and non-laser directed energy weapons. Mission effectiveness in environmental extremes should be improved by products to assess hydration status of field personnel, expert systems for selection of performance sustaining dietary supplements, a hand-held heat stress calculator for work-rest cycles and hydration requirements, and ultimately, personal thermal control systems. Advances in the neurosciences are essential for the prevention of combat stress reactions and technologies to promote soldier alertness and enhanced performance. Future options for field nutritional strategies will be expanded by biotechnological approaches.

Integrated Systems of Medical Chemical and Biological Defense. Although chemical and biological defense are often referred to together (i.e., ChemBio or CB Defense), the medical chemical and biological defense programs are separately managed. In contrast to the similar approaches used by the nonmedical program for individual and collective protection against chemical and biological threats (e.g., protective masks), the medical programs utilize different technological approaches to the challenges they face, shaped by differing legal and regulatory influences. These approaches are suited only for integration within each program, not across programs, for management purposes. Nevertheless, from the standpoint of the end user, the soldier in the field, these separate programs provide an integrated and flexible system of protection against both chemical and biological threats.

In contrast to most medical programs, the products of the medical chemical and medical biological defense programs are heavily integrated into nonmedical NBC defense systems, and are often issued as soldier, rather than medical, items. The flexibility afforded by the interaction between capabilities provided by medical protection and by individual or collective protective equipment can significantly enhance mission effectiveness during chemical or biological warfare. Medical products form integral components of both the Soldier Modernization and NBC Defense families of products developed by the Army Materiel Command. Coordination among medical and nonmedical programs is achieved through formal and informal interactions and joint planning at many levels, from individual labs and centers to Joint Service.

Technology demonstrations during the POM years will assess the feasibility of a new generation of medical approaches to protection from the incapacitating and lethal effects of chemical and biological threat agents. The provision of significant protection against the effects of moderate levels of threat

agents through medical prophylaxes will enhance force effectiveness by allowing commanders to adopt lower levels of Mission-Oriented Protective Posture. Among the key next-generation products will be improved pretreatments for nerve agents that will provide the soldier significant protection. For biological threat agents, the availability of a first generation of medical prophylaxes to toxins will provide significant protection. Improved antidotes and therapeutic measures will further enhance force effectiveness by increasing the rate at which casualties are returned to duty, and will lessen the evacuation burden on both medical and nonmedical personnel by reducing the proportion of non-ambulatory casualties.

Future products within these families of systems should provide protection against an expanding range of chemical and biological threat agents. In addition to the provision of prophylaxes, pretreatments, antidotes, and therapeutics effective against threats not previously addressed (i.e., emerging threats), there should be an acceleration in the development of single products effective against broad classes of threat agents (e.g., polyvalent vaccines, improved antiviral drugs). To aid in the treatment of casualties, diagnostic equipment should be developed that better identifies both the specific threat agent employed and the nature and extent of the injury. Achievement of these objectives will require concerted efforts to use emerging technologies, especially biotechnology and neuroscience, in military medical products.

TECHNOLOGY BASE FUNDING

Investment in the Army's 6.1 and 6.2 funding categories, which represented as much as 3 percent of the Army's Total Obligation Authority (TOA) in the 1960s, has been declining steadily since FY78 (see Figure IV-14). Continued decrements, coupled with demands to support high-priority, near-term needs, have seriously damaged program stability and resulted in a weakened technology base. A major risk is that needed efforts lack the "critical mass" of resources that they require if they are to be productive. Increased support and stability in the Army technology base are prerequisites for scientific and technological competitiveness and superiority.

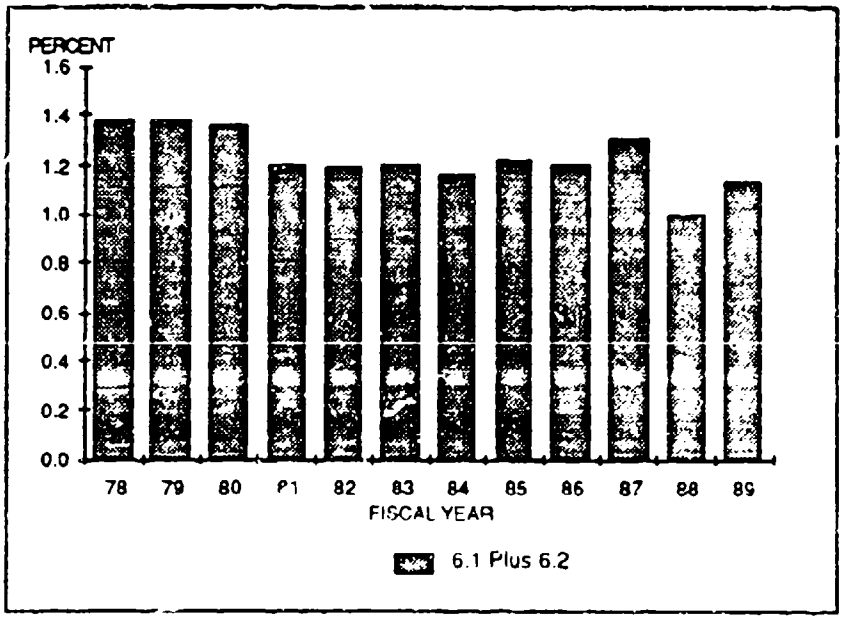


Figure IV-14. Army Technology Base (6.1 plus 6.2) Percent of Army Total Obligation Authority

To attain a measure of stability for the Army's 6.1 and 6.2 programs, the ATBMP TBIS sets a goal for minimum sustained funding at the Army's FY90 level, with no less than zero percent real growth maintained thereafter. It is hoped that the technology base will show a 2 percent real growth for FY92-97. Although not an ideal situation, this investment strategy aspect is consistent with the long-term nature of basic and applied research and will permit the Army's scientists and engineers to conduct long-range planning to ensure that the technologies required to address future warfighting needs will be available.

In FY88, the Total Army Technology Base comprised 11.9 percent of the entire DoD Technology Base funding (e.g., $8,661.1 million FY88). The Army Medical Technology Base funding of $187.4 million represents 17.5 percent of the Total Army Technology Base in FY88 but only 14.2 percent ($176.6 million) in FY90. Allocation is in line with Army goals (Figure IV-15).

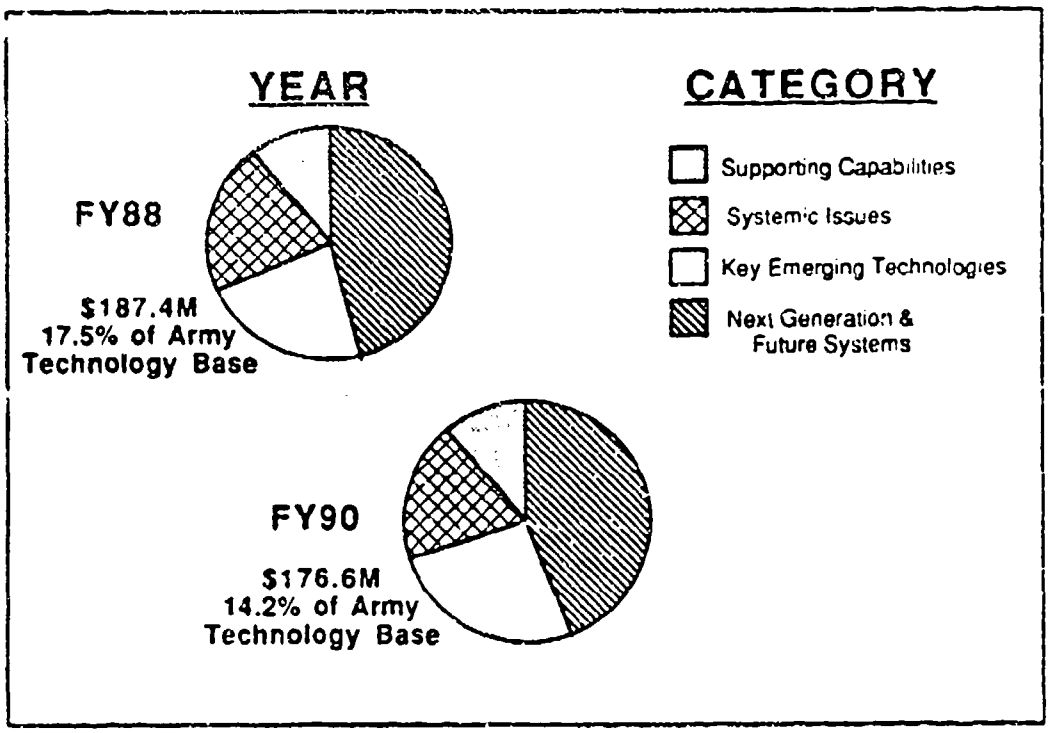


Figure IV-15. Medical Technology Base Resource Allocations by Category

From the late 1970s to the mid 1980s, funding for medical R&D grew in response to the accumulation of expanded missions, primarily for Joint Service Programs. The funding profiles shown in Figures IV-16 and IV-17 demonstrate this growth in both current and constant dollars and as a percentage of the Army's total investment in R&D. Although the number of missions has remained constant since 1986, the funding has decreased, both in terms of real dollars and as a percentage of the Army's R&D investment. The increases in funding projected for FY93-94, based on the 90-94 POM, are likely to be optimistic in the current fiscal environment.

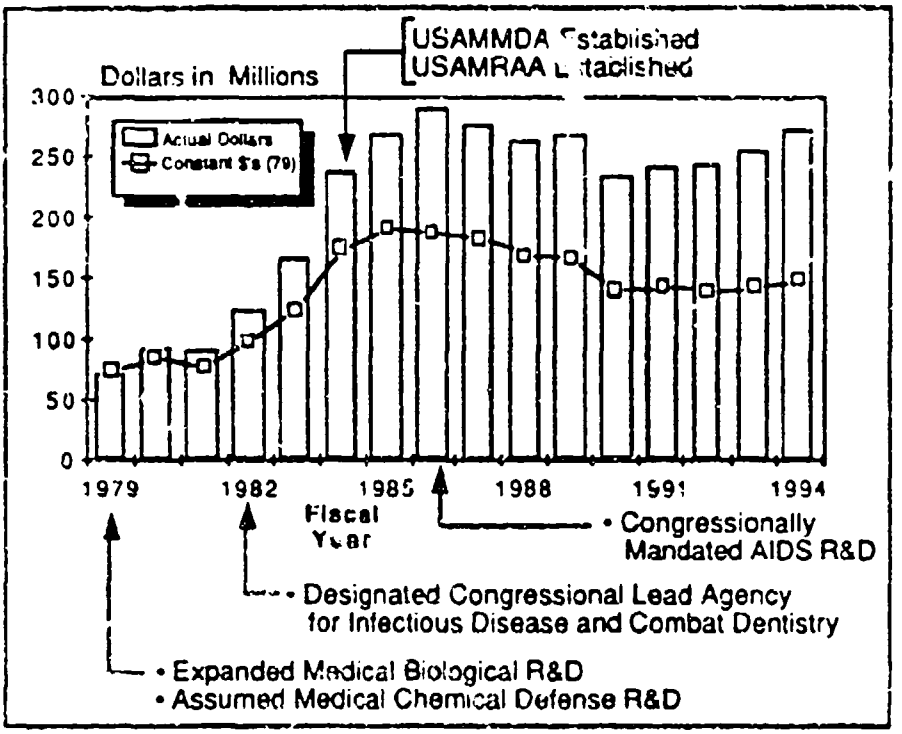


Figure IV-16. RDT&E Funding: Historical Perspective

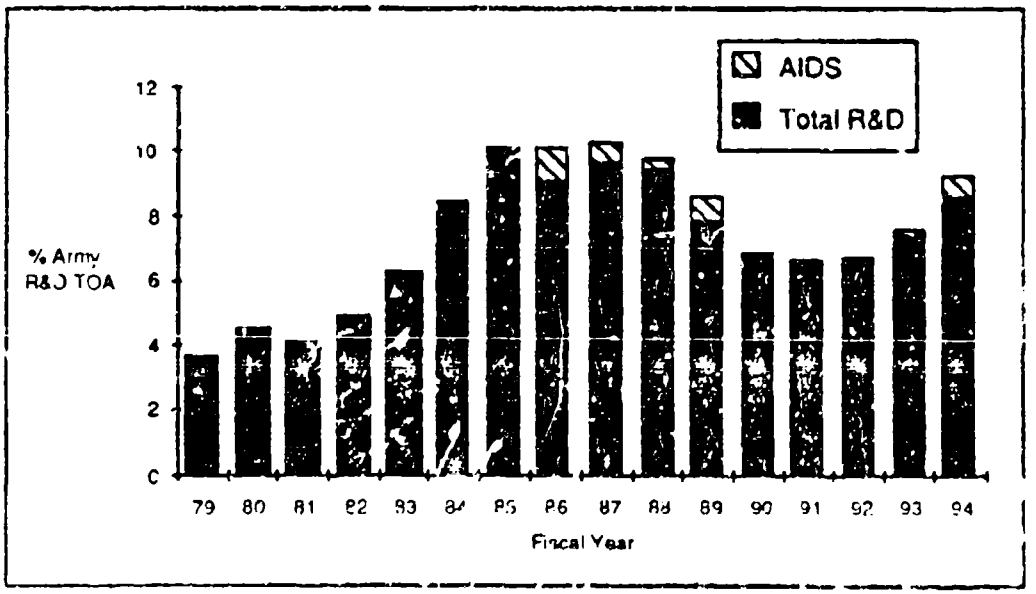


Figure IV-17. Medical R&D Funding: Percent of Army R&D TOA

LEVERAGING

An essential component of the Army TBIS is to ameliorate austere technology base Army funding projections by leveraging non-Army technology base programs; i.e., using "Other Peoples Money" (OPM). Several sources of funding within the DoD can be accessed to supplement the Army's RDT&E funding. One is the Army's participation in the Balanced Technology Initiative (BTI) Program. Another source is funding provided by the Defense Advanced Research Projects Agency (DARPA), and another through use of congressionally approved funding for international cooperative RDT&E.

Balanced Technology Initiative

In FY87, Congress established the BTI to provide additional support for the restoration of the conventional defense technology base and for the development of technologies that promise to significantly advance our conventional defense capabilities. The technology base budget for BTI for FY89 is $338 million; of this, $71 million was provided directly to the Army, and $203 million to programs relevant to Army needs.

International Cooperative RDT&E ("Nunn Money")

In the arena of international cooperative agreements, the Army position is that there should be two-way flow of ideas and information, and cost sharing is encouraged. International cooperation in RDT&E offers an opportunity to capitalize on advanced technology developed by our allies, and to make programs more affordable by spreading costs among a number of partners. As a means of encouraging more international cooperation between the United States and its allies, Congress passed the "Nunn Amendment" to the FY86 DoD Authorization Act which, for the first time, provided monies designated specifically for cooperative international RDT&E ventures. This annual infusion of congressionally approved funding has been supplemented by Defense Guidance which establishes an FY94 target of 10 percent of total RDT&E to be set aside for cooperative programs. By FY2000, the goal is to reach 25 percent.

To optimize the use of additional yearly funding, and the technology advances and nondevelopmental items (NDIs) of our allies (as well as their investment), it will be essential to focus on those opportunities offering the greatest return.

Accordingly, R&D projects selected by the Army to share in the allocation of "Nunn Money" will be of such importance that they would be pursued as "U.S. only," even if overseas partners could not be attracted. The Army's International Cooperative R&D Program is managed by the OASA(RDA). Selection criteria are that each cooperative R&D project must:

- Contribute toward improving the conventional defense posture (including chemical and biological defense);
- Meet a defined U.S. requirement;
- Occupy a priority position in the Army's Long-Range RDA Plan;
- Be suitable for collaboration;
- Be supported within the Army, the OSD, and the Congress;
- Be funded in the Five-Year Defense Plan, or be scheduled for funding submission;
- Be of interest to potential partners who have funds and are willing to share the project cost on an equitable basis; and
- Be acceptable for either U.S. or foreign lead/management.

Leveraging and the USAMRDC

Given the increasing likelihood of level or reduced Army funding over the near- to mid-term, leveraging will become an essential element of the TBIS for medical technology base programs. The Nunn Money program is just one of many ways to accomplish this objective. More broadly, the USAMRDC leverages technology dollars through academia and other Government agencies at both the national and international level, and through industry. The objective is to access, with a relatively small contract investment, the extensive and costly data and knowledge base that is available outside the Services. Figure IV-18 illustrates some of the means used to gain that leverage.

- National
  - Academic institutions through contracts, Intra-governmental Personnel Act (IPA), fellowships
  - The National Academy of Sciences (NAS)/the National Institutes of Health/the National Science Foundation (NSF) through Military Interagency Purchase Requests (MIPRs), data bases, seminars, exchanges
  - Government agencies through MIPRs, the Defense Technical Information Center (DTIC)
- International
  - Technical DEAs
  - Cooperative development programs
  - NATO comparative testing and foreign material evaluations
  - Symposia and meetings
  - Foreign academic contracts
  - European Research Office
  - Scientific and technical centers, Europe and Far East
  - World Health Organization (WHO), Pan American Health Organization (PAHO)
- Industrial
  - Cooperative Research and Development Agreements
  - Small Business Innovative Research Program

Figure IV-18. Leveraging R&D Dollars

The USAMRDC encourages research in relevant fields at colleges and universities, and cooperates with research efforts at the NIH, the NSF, and other Government agencies. The USAMRDC research programs complement and exploit civilian science and technology efforts over the full research and development spectrum (6.1 through 6.4). The commercial sector is encouraged to address problems of military interest through the Small Business Innovative Research Program.

The Federal Technology Transfer Act, passed to enhance technology transfer from Federal laboratories to the private sector, is the authority for numerous USAMRDC Cooperative Research and Development Agreements (CRDAs), primarily with pharmaceutical, chemical, and biotechnology firms. Funds, personnel, and equipment may be provided to the Government laboratory by industry to stimulate collaborative research and development; the Government may grant an exclusive license to a firm for inventions conceived or reduced to practice during performance of the CRDA. The CRDAs stimulate commercial development, as well as the evolution of military products.

Medical research and development is an international program that most typifies broad and effective current and potential opportunities both in developing and developed nations; hence Army technology base initiatives often have high pay-off and leverage potential. The USAMRDC participates in information and data exchange programs, cooperative developments, NATO comparative tests and foreign weapons evaluations, and symposia and meetings. Foreign academic contracts may be awarded where payoffs are evident.

The Medical Department (USAMRDC) is in a position to leverage R&D dollars as responsible agency for the Army in its role as lead or executive agent for several DoD programs. These are AIDS research, Infectious Diseases, Combat Dentistry, and Biological-Chemical Defense.

Use of OPM to sustain the momentum of military medical R&D will become increasingly important. Augmentation of Congressionally-approved programs with funding from non-Army sources, such as the investment by the NIH for Human Immunodeficiency Virus (HIV) research on pediatric cases, is appropriate when such incentives complement but do not have an adverse impact on military-unique aspects of the program. The USAMRDC managers and scientists are encouraged to identify alternative sources of funding and other initiatives that will effectively leverage the investment in the technology base that the Army can afford.

Section V

MANAGEMENT OF MEDICAL R&D PROGRAMS

INTRODUCTION

Scientific and management personnel of the U.S. Army Medical Research and Development Command are active in every phase of the R&D process, from identification of problems to provision of effective solutions. The management structure has been optimized to facilitate the transition of medical solutions, both materiel and informational, to the user. This section describes the organization, program, management, and execution of medical R&D programs.

ORGANIZATIONAL FRAMEWORK

Office of the Secretary of Defense

The technology base management oversight functions of the DoD are performed by OSD through the Office of the Director of Defense Research and Engineering (ODDRE). Within this office, responsibilities overlap (Figure V-1). All medical technology base programs are overseen by the Director of Environmental and Life Sciences; the 6.1 Basic Research programs are under the additional oversight of the Director of Research and Laboratory Management. Chemical and biological defense issues are often coordinated with the staff of the Deputy Assistant to the Secretary of Defense (Chemical Matters).

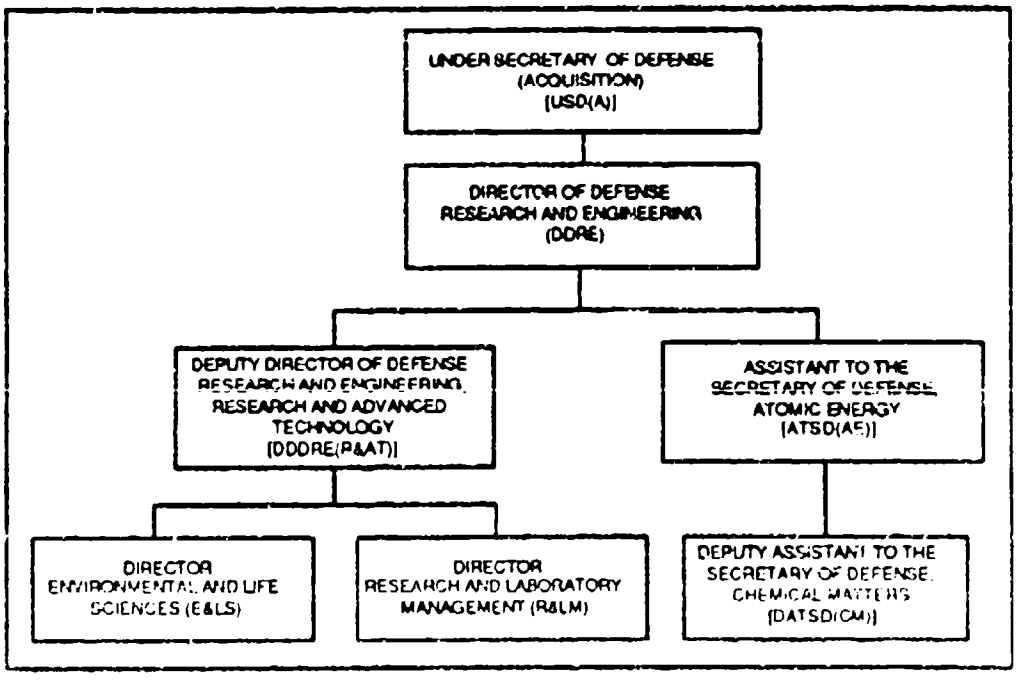


Figure V-1 Organizational Structure for the Office of the Under Secretary of Defense (Acquisition) [OUSD(A)]

Headquarters, U.S. Army

The Goldwater-Nichols DoD Reorganization Act of 1986 (P.L. 99-433) resulted in placement of responsibility for all research, development, and acquisition functions within the Army Secretariat (Figure V-2). The rationale for this reorganization was that the primarily "civilian-like" nature of these functions mandated civilian (i.e., Secretary of the Army), rather than military (i.e., Chief of Staff) management and control. The office and position of the Deputy Chief of Staff for Research, Development and Acquisition (DCSRDA) was dissolved and its functions moved to the Office of the Assistant Secretary of the Army for Research, Development and Acquisition. The three-star billet of DCSRDA was retained in the position of Military Deputy to the Assistant Secretary of the Army for Research, Development, and Acquisition [ASA(RDA)] (Figure V-3); other decision and support elements and responsibilities were split between the OASA(RDA) and the Army Materiel Command. Thus, the Army Secretariat now controls RDA policy and is the approval authority for resource allocation. The role of the Army Staff is restricted to approval of requirements, priorities, and test and evaluation functions. The Secretariat and Staff elements are thus partners in the PPBES which matches Army R&D requirements to resources.

As the Army Staff focal point for all medical programs, TSG is responsible for recommending research priorities for medical R&D requirements to the DCSOPS (AR 71-9). The Commander, USAMRDC, by virtue of the authority TSG has delegated to him as the Assistant Surgeon General for Research and Development (ASGRD), has broad authority to initiate and coordinate with HQDA, other services, and the DoD on substantive policy matters and issues. To assist in performance of these duties, liaison elements representing the ASGRD are co-located with the Army Staff (OTSG) and Secretariat [OASA(RDA)]. The ASGRD helps shape guidance and policy for all Army R&D through participation in the ASA(RDA)'s Technology Base Investment Council.

Within the OASA(RDA), the Deputy for Research and Technology (SARD-ZT) is responsible for oversight, planning and policy for technology base programs (6.1-6.3A). Figure V-4 shows the functional organization of the Office of the Deputy for Research and Technology, Office of the Assistant Secretary of the Army (RDA). The DA Technology Staff Officers (TSO) are responsible to the Director for maintaining liaison with the developing agencies, for developing top-down guidance, for recommending resource allocations, and for overseeing the execution of R&D programs. Except for four, the DA TSO positions are filled by civilians permanently assigned to the office of the Director, Army Research and Technology. These TSOs are assisted by liaisons and interns from the developing agencies. In a unique arrangement, officers assigned to the liaison office of the ASGRD (DASG-RDZ) fill the positions of the DA TSOs for Medical R&D and Chemical-Biological Defense Research (medical and non-medical) at the invitation of the Deputy for Research and Technology. The senior officer assigned to the liaison office also functions as the primary liaison between the OTSG and the ASA(RDA).

The Pentagon liaison office of the ASGRD also maintains close coordination with other HQDA staff elements. The ASA (Installation, Logistics, and Environment) has HQDA responsibilities for environmental and occupational health and safety policy. The Deputy Chief of Staff for Personnel (DCSPER) has overall responsibilities for the MANPRINT process, for which the TSG provides health hazard assessments. In response to continuing congressional and public interest in medical R&D programs, close liaison is maintained with the Office of Congressional Legislative Liaison and the Army Public Affairs Office. There is also frequent interaction with the Army Safety Office, the staff elements of the Director, Space and Special Weapons in the Office of the Deputy Chief of Staff for Operations and Plans (ODCSOPS), and the staff of the Director, Program Analysis and Evaluation in the OCSA. Also, the medical R&D liaison staff works closely with staff elements with the Office of the Secretary of Defense in coordinating policy and guidance issues which impact medical R&D.

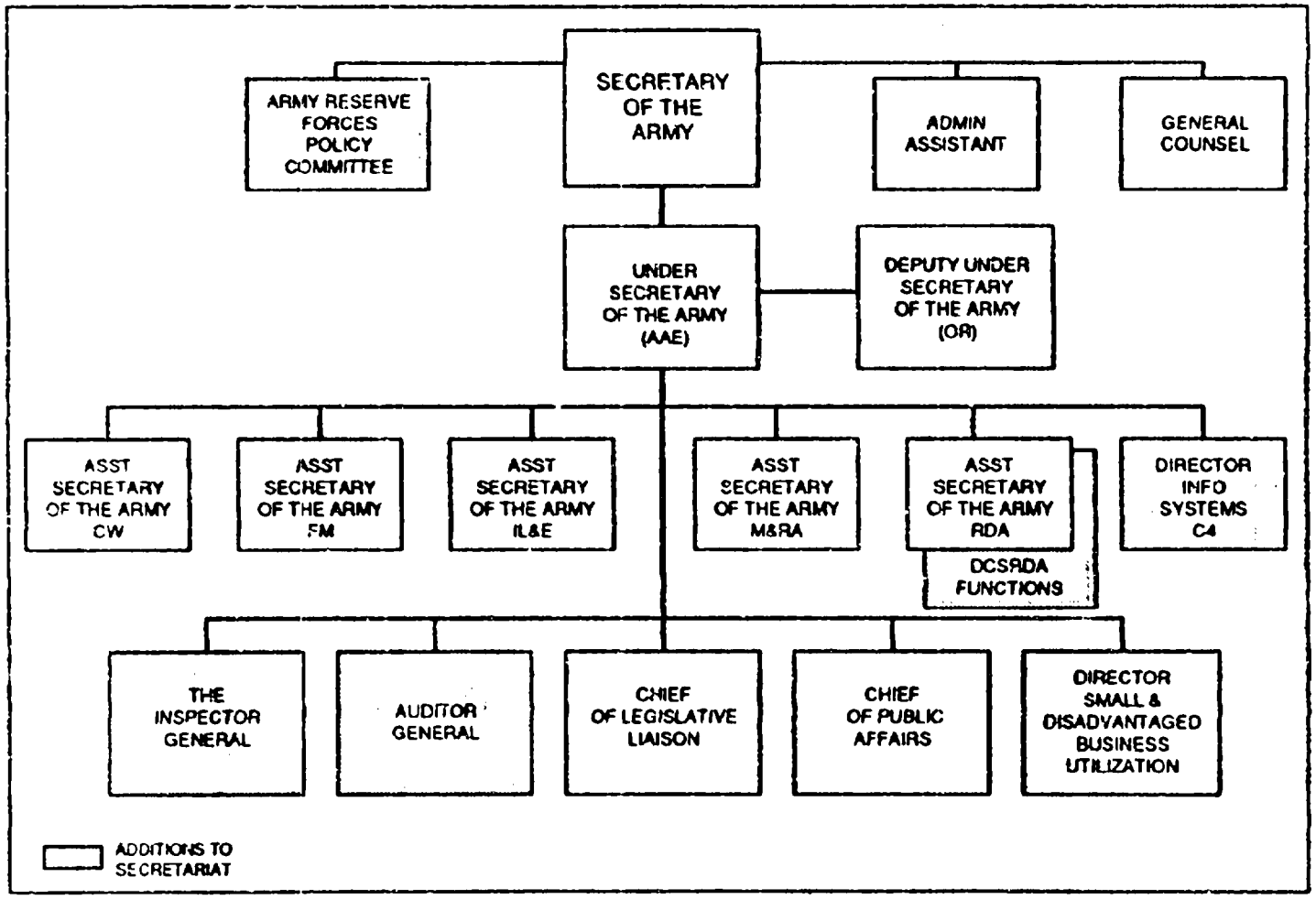


Figure V-2. Army Secretariat Organization
(New Organization)

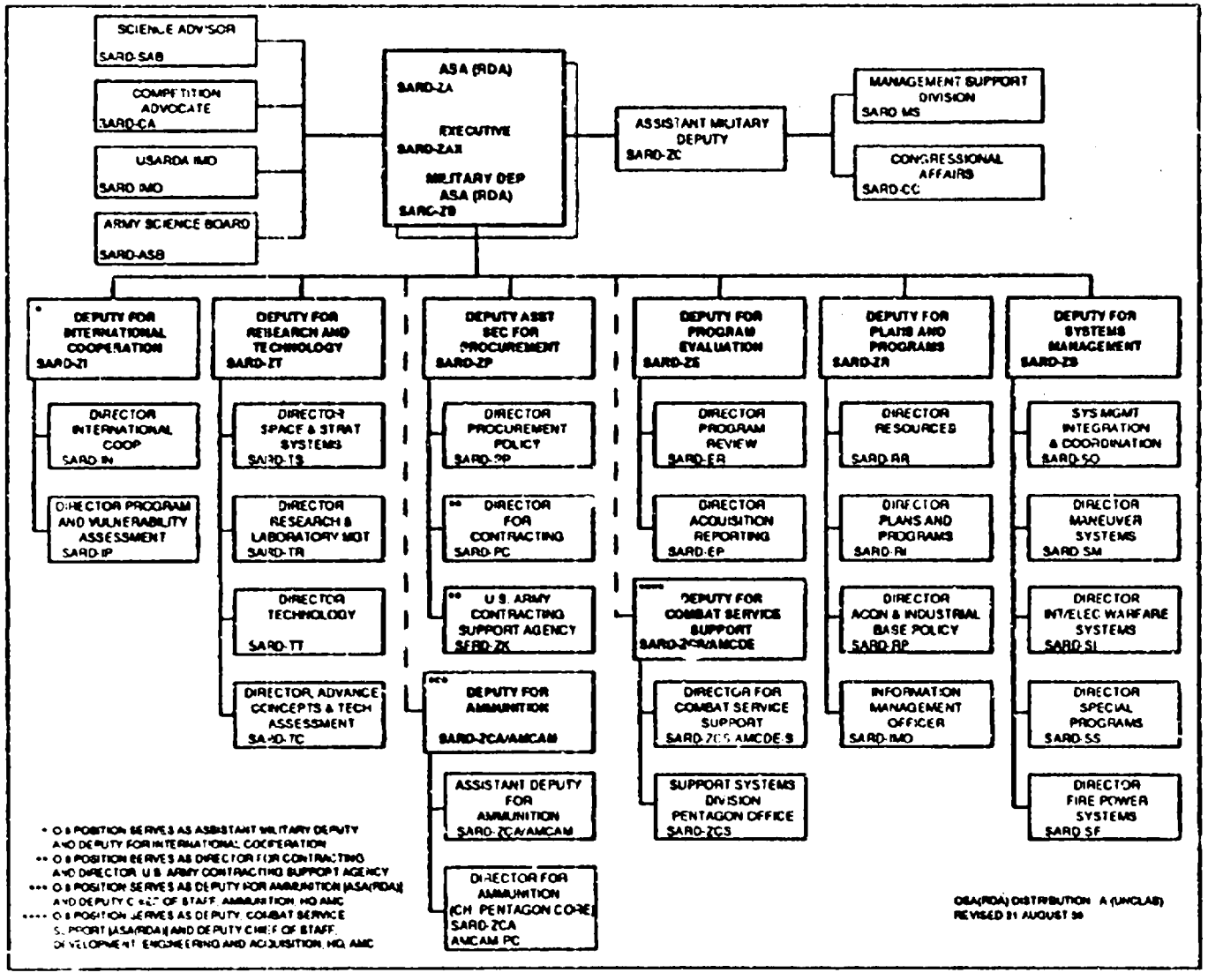


Figure V-3. ASA(RDA) Organization

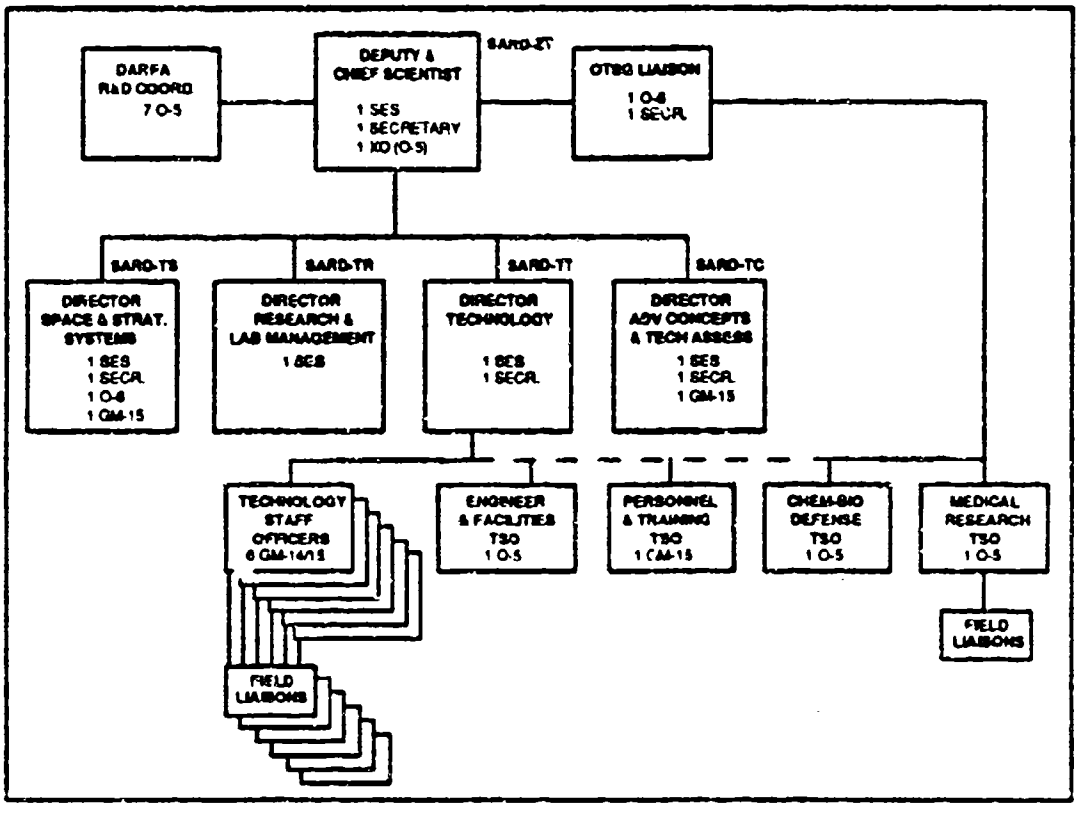


Figure V-4. Deputy for Research and Technology, Office of the Assistant Secretary of the Army (RDA)

U.S. Army Medical Research and Development Command

The USAMRDC, a field operating agency (FOA) of the OTSG, was established in 1958. The command was formed to direct worldwide Army efforts to improve preventive medicine measures and rapid-treatment techniques. The roots of the new command lay in the establishment of the Army Surgeon General's Medical Research and Development Board in 1943. The research missions in medical chemical and medical biological defense, initially part of the medical department's responsibilities, were recaptured by The Surgeon General in the 1970s after a period in which these functions were performed under the supervision of the Chemical Corps. Headquarters, USAMRDC, moved to Fort Detrick, Maryland, in 1978. Figure V-5 presents the organizational structure of USAMRDC.

Although the USAMRDC's primary organizational interface to HQDA and other services is through the OTSG, it also interfaces directly with other Army elements and other Government agencies. Medical R&D programs are planned, programmed, and executed in coordination with other DoD organizational elements which advise on, oversee, and often approve policy matters, programmatic content, and resource allocations for medical as well as non-medical R&D. An understanding of the roles of these diverse elements is important to the efficient execution of the USAMRDC's research mission.

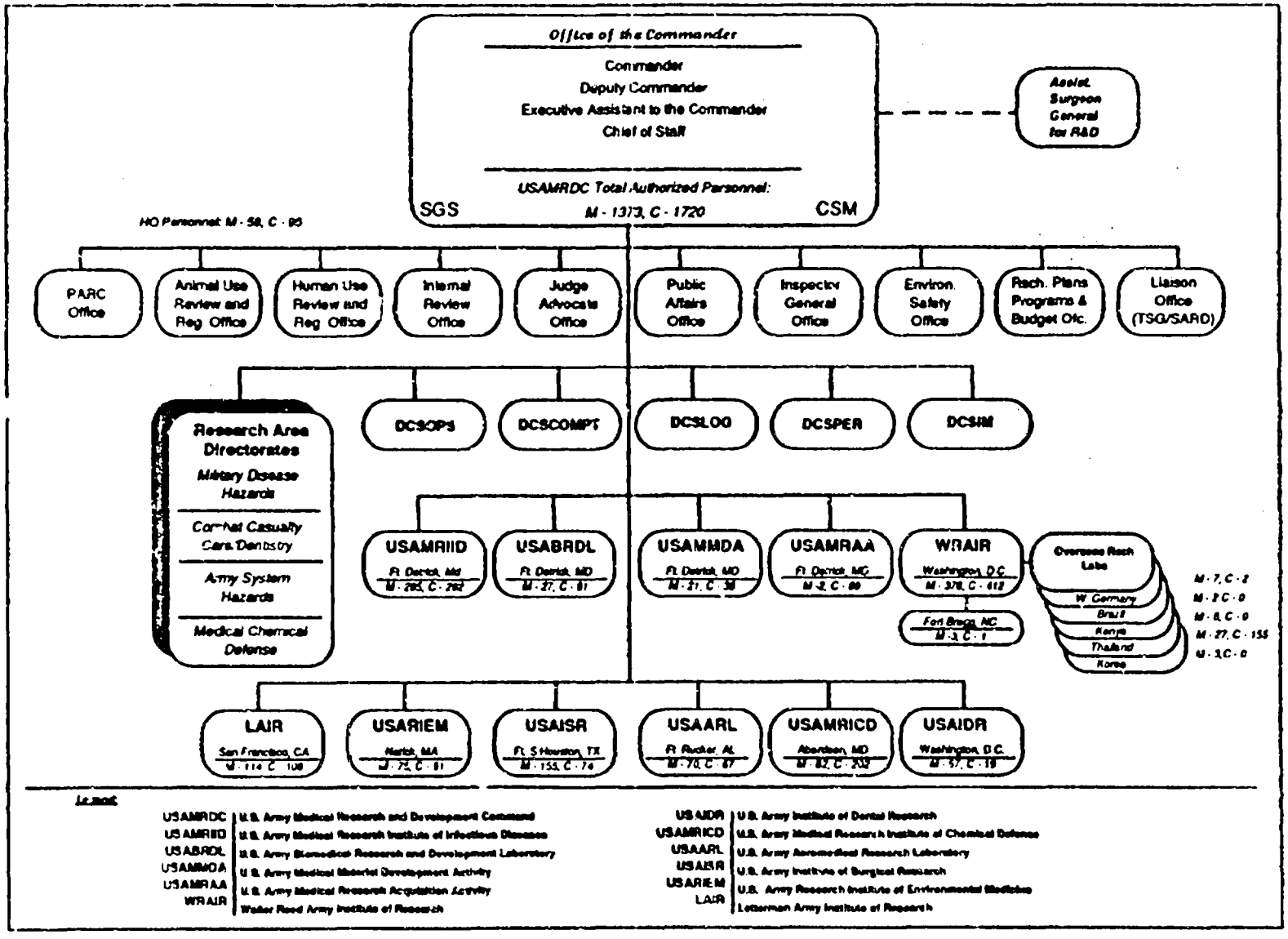


Figure V-5. Organizational Structure of the USAMRDC

JOINT SERVICE RESPONSIBILITIES

Armed Services Biomedical Research Evaluation and Management (ASBREM) Committee

The Congressionally-mandated ASBREM Committee was chartered in 1981 under each of the Secretaries of the Military Departments responsible for research, development, and acquisition. In recognition of the continuing need to facilitate management coordination, improve information exchange, and accomplish biomedical RDT&E activities pertinent to the missions of the Army, Navy, and Air Force, the Commander of the USAMRDC, the Commander of the Naval Medical Command for Fleet Readiness and Support, and the Commander of the Air Force Human Systems Division agreed to meet, periodically, in joint session. The objectives of the Committee are:

- To increase the cost effectiveness of resource utilization through efficient use of personnel, intelligence, facilities, equipment, supplies, and services;
- To provide a mechanism to address organizational roles, conduct management studies, and resolve service organization/functional alignment issues;
- To ensure program relevance and to obviate duplication among DoD's and other agency's programs through timely reviews of requirements and program plans; and
- To define Service issues which require resolution/coordination with other Federal agencies.

The continuing business of the ASBREM Committee is conducted through a joint secretariat, composed of a personal representative of each Military Department's ASBREM member and seven Joint Technology Coordinating Groups (JTCGs). Each JTCG is composed of biomedical research managers from the respective Military Departments, and appropriate laboratory personnel. JTCGs exist for Dentistry, Infectious Diseases, Medical Chemical Defense, Medical Biological Defense, Human Systems Technology, Combat Casualty Care, and Ionizing Radiation. The ASBREM Committee is a premier example of Joint Service program coordination and has been cited as a model for other science and technology disciplines.

Executive Agent and Lead Agency Responsibilities

The Army serves as the DoD Executive Agent or Lead Agency for many research areas. As Executive Agent, the Army is responsible for managing all research in a specified area, except that for which the requirements are Service-unique. When designated as Lead Agent, the Army has additional responsibilities for conducting research which addresses requirements that may be unique to another Service, often funding other Services' R&D programs in that area.

Infectious Diseases. The primary thrusts of this DoD Lead Agency research program (ref. HR Report #97-333, DoD Appropriation Bill, 1982) are development of: (1) preventive measures against infectious diseases through discovery, design, and development of prophylactic, therapeutic, and treatment drugs for relevant diseases and/or studies of control measures against infectious disease vectors; (2) improved diagnostic techniques and treatments for infectious diseases; and (3) novel, improved drug delivery systems which reduce toxicity and more efficiently deliver prophylactic/therapeutic drugs to active sites.

Combat Dentistry. Research in the area of combat dentistry, another Army lead agency function (ref. HR Report #97-333, DoD Appropriation Bill, 1982), focuses on the development of simplified procedures for care of combat-type maxillofacial wounds and injuries and on preventive dental medicine.

Chemical/Biological Defense. The Army is the Executive Agent for Biological and Chemical Defense (DoD Directive 5160.5, 30 March 1976 (as amended)). The USAMRDC performs the Army's Executive Agent responsibilities in medical defense against these threats. The Army also serves as lead requirements coordinator for the Joint Services and executes formal coordination through the Joint Services Agreement and the ASBREM. In addition, research is coordinated with quadripartite and NATO nations through meetings and Data Exchange Agreements.

Nutrition. The Surgeon General of the Army is the DoD Executive Agent for nutrition (DoD Directive 1338.10). Responsibilities include conducting research, ensuring adequacy of the Armed Services diet, and monitoring the nutritional status of personnel. The USAMRDC executes these responsibilities and the U.S. Army Research Institute of Environmental Medicine is the lead laboratory for nutrition research.

Military Human Immunodeficiency Virus (HIV) Research (AIDS). Congress directed that the Army serve as the DoD Lead Agency in a research program on AIDS, supplementing and enhancing the national AIDS program. This program comprises five critical areas: (1) the progression of disease; (2) the improved diagnostic methods (e.g., assays); (3) the epidemiology in the military population; (4) a military center to test therapeutic drugs in cooperation with the Public Health Service; and (5) the evaluation of vaccines and conduct of clinical trials.

PROGRAM AND EXECUTION MANAGEMENT

The USAMRDC is responsible for planning, coordinating, managing, executing, and reviewing the U.S. Army Medical Department's RDT&E programs from program category 6.1 through 6.4. Figure V-6 summarizes the mission, functions, and goals of the USAMRDC.

Mission activities of the USAMRDC are organized into four research programs: Military Disease Hazards Research (Infectious Disease, Medical Biological Defense, and Military AIDS), Combat Casualty Care Research, Medical Chemical Defense Research, and Army Systems Hazards Research. Current activities and future directions are described in Section VI.

HQ, USAMRDC

Command and Special Staff. The Commanding General (CG), USAMRDC, fulfills five assigned major and related functions: he is a developer, director, Assistant Surgeon General for Research and Development, Head of Contracting Activity (HCA) and Commander, USAMRDC. His roles require coordination and interface with a broad spectrum of national, international, public, and private agencies.

The CG delegates RDT&E program planning, budgeting, and management authority to Research Area Directors, who, with subordinate commanders, are responsible to the Deputy Commander for the overall staff management of the medical RDT&E program. The Director of the Research Plans, Programs, and Budgeting (PPB) provides for central coordination of all PPB-related actions.

Sound management practices dictate that the CG organize and staff his HQ in a manner that best facilitates the accomplishment of his various roles and responsibilities. The immense demands of the five roles upon HQ require a flexible Command manpower management policy. By integrating functions associated with particular roles into its day-to-day activities, HQ staff support the CG.

Each of the CG's roles have different functions.

As Medical Materiel Developer, the CG plans, programs, budgets, and executes a medical RDT&E program to meet Army and Joint Service needs; acts as DoD Lead Agency/Executive Agent; establishes program guidance and priorities; and provides worldwide technical and professional guidance and assistance in medical materiel development.

As Director, he is the principal staff agent for medical RDT&E for medical aspects of Army RDT&E, and is the program director for medical P-6 funds for the OASA(RDA).

As the ASGRD, the CG serves as Chairman of the Human Subjects Research Review Board, acts as senior advisor on Medical RDT&E to TSG, the CSA, the AAE and the CG, Army Materiel Command, and conducts the Manpower Survey Program for the USAMRDC.

MISSION

of the

U.S. Army
Medical Research and Development Command

Plan, Coordinate, Manage, Execute, and Review the U.S. Army Medical Department's Research, Development, Test, and Evaluation Program

FUNCTIONS

- **Develop and Maintain a Military Medical Science and Technology Base**
- **Act as Materiel Developer for the Surgeon General**
- **Obtain Biomedical Data Necessary for Setting Health and Safety Standards for Army Personnel and Materiel**
- **Provide Health Hazard Assessment for all Army Materiel Developers**
- **Provide Technical Expertise for Development of Operational Concepts and Doctrine**

GOALS

Provide the Materiel and Informational Products Necessary to:

- **Prevent Casualties - or-**
- **Rapidly Return Casualties to Duty**

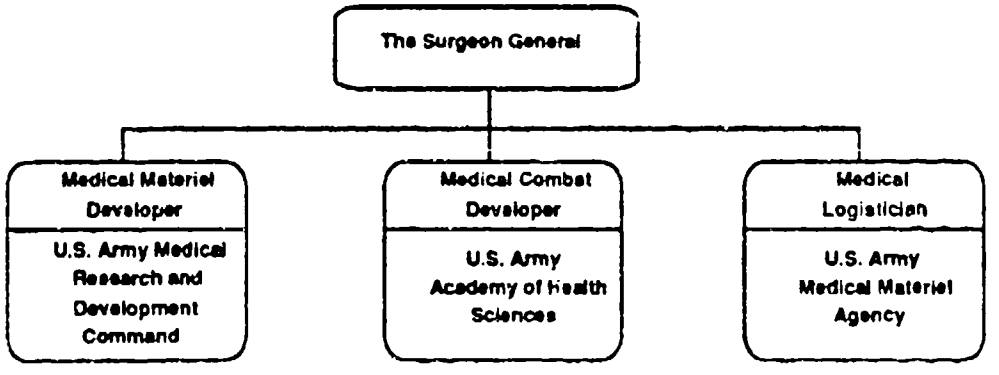


Figure V-6. Mission, Functions, and Goals of the USAMRDC

As the HCA, he ensures that all biomedical research and development contracts and purchases made by the Contracting Activity are in accordance with applicable Federal regulations, supplements, and directives; maintains surveillance over contracting performance, and ensures that opportunities for full and open competition exist.

As Commander of the USAMRDC and the HQ unit, the CG's responsibilities are: to direct and supervise the HQ staff, to establish functions for the Command Group, to exercise command and control over commanders of subordinate USAMRDC units, and to manage manpower requirements and authorizations allocated to subordinate USAMRDC units.

The effective execution of the CG's responsibilities requires the able assistance of many varied staff elements. Although complete descriptions of the roles and responsibilities of each element are beyond the scope of this plan, descriptions of several staff positions and elements central to planning and staff management of the technology base research program are included below.

The Deputy Commander (DCO), who is also Deputy ASGRD, assists the CG. He has broad oversight responsibilities for the management aspects of the director, developer, commander, and ASGRD roles. The DCO reports to the CG and commands in his absence. The primary functions of the DCO are: to act as the principal HQ advocate for science and technology; to serve as Chairman of the Program Budget Advisory Committee (PBAC); to provide guidance and oversight regarding science, technology and materiel development efforts in Joint RDT&E programs recommending long-range priorities and mission objectives; to exercise supervisory responsibilities for Command policy, plans, and procedures governing R&D; and to ensure that the full capability of command assets is dedicated to solving Army deficiencies.

The Director, Research Plans and Programs, manages the Command's input to the Army Planning, Programming, Budgeting, and Execution System (PPBES), ensuring that resource requirements are identified and that available resources are planned and programmed for optimum utilization. This office interfaces with other staff offices and subordinate units as necessary. The office coordinates closely with the RADs to ensure the evolution and integration of plans into effective and timely programming actions; in addition, it provides the RADs the strategic planning and resource management systems and the framework within which to make program decisions.

The Office of the Assistant Surgeon General for Research and Development reports to the Deputy Commander/Deputy ASGRD, and serves as the principal policy advisor and interface for special actions concerning Medical RDT&E issues with the OTSG, the OASA(RDA), the OSD, other Army staff agencies and Federal agencies, the Congress, and the White House Staff. Functions of this office include staffing of the liaison offices in the Pentagon. (Responsibilities of the liaison offices are described above.)

The Office of Human Use Review administers TSG's procedures for review and approval of Army research and testing protocols involving human subjects. Reviews include testing of investigational new drugs and devices and other projects involving research with human subjects. Responsibilities are: to complete a preliminary review of all human research proposals for compliance with Army and Federal regulations; to assist in the preparation, review, and submission of all TSG-sponsored notices of Claimed Investigational Exemption for a New Drug to the FDA; to maintain official U.S. Army files for all research protocols involving the study of investigational drugs and devices in humans; to provide consultation on human research issues to commanders and investigators throughout the AMEDD and other Army agencies; and to maintain liaison with other Federal agencies regarding human research policy and directives. The office provides consultative and administrative support to the DoD on selected projects concerning regulations on the issues of human research subjects and accountability of investigational drugs. It also maintains a centralized volunteer registry for USAMRDC-sponsored research

The Principal Assistant Responsible for Contracting (PARC) is delegated authority to carry out acquisition functions; he ensures that the contract process is in accordance with applicable Federal Acquisition Regulations, supplements, and directives. The PARC prescribes and publishes Command policies and procedures; also this office reviews staff oversight responsibility for contracting activities within the Command. Other PARC functions are: to provide consultation throughout the Command on contracting policies, procedures and related issues; to monitor staff; serve as the Command focal point for the contracting processes of the extramural research contract program; to establish and maintain continuing liaison with academia and industry and participate in R&D conferences and exhibits; to assist rejected firms to qualify for future awards; and to advise the civilian sector how to do business with the USAMRDC.

The Animal Use Review Officer monitors DA procedures for review and approval of Army research protocols involving animals. Reviews include investigational drugs and devices, tests, and other projects involving animal research. To carry out this responsibility, the assigned individual provides advice to RADs, the Acquisition Management Office, commanders of subordinate units, and contractors; serves as point of contact for actions related to AR 70-18, "The Use of Animals in DoD Programs"; reviews all proposals that require research with laboratory animals for compliance with applicable laws, regulations, and guidelines; participates with the DA in development of policy relating to animals in research and development; and provides applicable information to laboratory animal veterinarians.

Research Area Directors (RADs). Four Research Area Directorates have staff responsibility for the management of the Command's research programs, and each is headed by a Research Area Director -- an officer scientifically qualified by education and experience. Each Research Area (RA) encompasses a specific mission within the field of military medicine. RADs are responsible for establishing goals and milestones for the execution of research programs, for maintaining an appropriate balance among technology base and development activities, and for identifying priorities and resources for transition items. To determine more effective ways to meet Army needs, they conduct continuing analyses of assigned mission area deficiencies and programs.

The relationship of the RADs to the other HQ staff elements is twofold. In the RAD role as the lead for program planning, the HQ staff supports and interacts with the RAD as directed by the RAD. The RAD ensures proper coordination with appropriate staff elements when program planning and management affect other staff offices. Conversely, other HQ staff elements have the lead in regulatory, compliance, and related Command management activities, and have authority to task the RAD for required input. Ordinarily, research area program priorities take precedence over such activities unless otherwise specified by the CG or Deputy Commander.

RAD-developed programs (6.1 through 6.4) include input from commanders of subordinate units before coordination with HQ staff. Laboratory commanders/directors are responsible for executing 6.1-6.3A-funded activities with programmatic direction from the RADs, and for participation in the execution of the 6.3B/6.4 development program. Execution responsibility for this program is delegated to the USAMMDA with RAD cognizance. The partnership between RADs and the USAMRDC commanders requires the joint identification and resolution of issues relating to program structure, content, and participation. The RADs have the lead in program planning; the commanders of the USAMRDC subordinate units execute programs.

One of the USAMRDC's primary advantages in the successful transition of products, is the existence of the RAD within its management system. The position of the RAD is unique among developing agencies in that a single manager is placed in a position to shape and influence the entire R&D process within a particular mission area, from requirements generation to fielding.

The Director for the Military Disease Hazards Research Program manages/directs research in such areas as disease threats, drugs and antisera for treatment and prevention of disease, diagnostic tests for

identification of microorganisms and toxins, insect repellents and disease vector control strategies, and vaccines for the prevention of disease. The staff responsibilities of this directorate extend to medical defense against biological warfare agents and the Military AIDS research program.

The Director for the Combat Casualty Care Research Program manages and directs research in resuscitation and early treatment of trauma, enhancement of wound healing, and improved materiel support of field medical units. Resuscitation and trauma research includes far-forward treatment of hemorrhagic shock, blood storage and processing, blood substitutes and the prevention of organ system failure. Wound healing research includes treatment and management of burns, new tissue growth in wounds, and the prevention of wound infections. Materiel support research includes diagnostic and therapeutic capability of field hospitals, reducing the need for medical resupply, and improved storage and handling of medical supplies. In addition, the Director manages and directs research in combat dentistry. Dentistry research includes such areas as methods and materials for the prevention and treatment of maxillofacial wounds; methods to identify soldiers at high risk for dental emergencies, and methods for treating these soldiers; dental materials and lightweight, low-cube, rugged portable equipment for battlefield use; methods to protect dental and medical equipment from electromagnetic pulse; and epidemiologic studies of maxillofacial wounds and dental emergencies which affect the soldier in combat.

The Director for the Army Systems Hazards Research Program manages/directs research in such areas as environmental physiology and medicine, human performance enhancement, mechanical forces and biodynamics, non-ionizing radiation bioeffects, personnel protective technology, and toxicology. In addition, he provides consultation services and/or liaison to other Army agencies and commands.

The Director for the Medical Chemical Defense Research Program manages and directs research toward a) the definition of the mechanism(s) of chemical warfare (CW) agents, and b) antidotes, prophylaxes, therapies, and new field medical materiel required for the prevention and treatment of the effects of CW agents. Other areas of study and development are: medical and scientific rationale for the management, diagnosis, prognosis, triaging, and treatment of CW casualties; medical and scientific rationale and the medical materiel required for the decontamination of CW casualties; medical life support materiel for the evacuation and treatment of mass CW casualties; and a biomedical data base for the medical aspects of chemical defense.

Lead Labs and Laboratory Commanders

The USAMRDC commanders have primary responsibility for ensuring that program execution objectives are met. Although the RADs exercise staff oversight responsibility in this regard, the USAMRDC commanders are accountable to the Commander, USAMRDC, for program performance. The commanders evaluate RAD guidance for program and resource impact; they respond with narrative comments and impact statements. The laboratory commanders coordinate resulting program inputs and resource conflicts with RAD and appropriate staff offices. Unresolved conflicts are referred to the CG.

The laboratory commanders and directors manage resources and in-house contract efforts which are responsive to military medical requirements and which meet the objectives and milestones set by RADs. They provide 6.1-6.3A program input to the RADs as well as advice and expertise to the Commander, USAMRDC, and the user community. The laboratory commanders are highly qualified uniformed scientists, who also act as technical directors, and often as the OTSG consultant in their respective mission area.

Acquisition Management Liaison Office (AMLO)

The AMLO is a staff function in the institute laboratory/activity. The precise role of each AMLO in the acquisition process depends upon the responsibility and authority delegated by the commander of the institute/laboratory/activity. The AMLO advises the Commander on contracting for scientific, technical and

analytical support. Typically, the AMLO participates with the PARC, RADs and representatives of the USAMRAA in the development of policies applicable to the extramural program, coordinates and facilitates the responsibilities of the Contracting Officer's Representative (COR) by providing assistance and training to increase effectiveness and ease the burden of the research scientist, who is the appointed COR; prescribes local policy in written directives and briefings, and arranges appropriate training; and ensures that the institute/laboratory/activity commander has concurred with the appointment of a member of his staff as a COR on a contract sponsored by another institute/laboratory/ activity.

Other tasks performed by the AMLO include: managing preproposal and proposal review; managing in-house meetings following scientific reviews to prioritize proposals recommended for support; communicating with prospective contractors as set out in the USAMRDC Standard Operating Procedure (SOP) 6, Procedures for Use of the Broad Agency Announcement; preparing procurement funding packages; performing preaward site visits; and managing the review of scientific reports. The AMLO performs fiscal management; maintains records; plans and programs incremental funding and supplements; and, upon completion of the research project, processes patent reports and equipment inventories.

Communications between the Contracting Officer and the COR are normally routed through the AMLO. Policy involving the COR as coauthor on contract-related manuscripts are established by each commander and AMLO, pursuant to procedures set out in the USAMRDC SOP 18, Procedures for Contracting Officer's Representative as Co-Author on Contract-Related Manuscripts.

Task or Technical Area Managers (TAM)

TAMs may be appointed by either laboratory commanders or RADs to assist in managing subareas of a particular research program. TAMs are delegated authority to plan and manage the execution of their area's extramural (and sometimes intramural) programs, tasks in which they work closely with the AMLOs and RAD staffs. TAMs responsibilities include: monitoring all research relevant to their mission subarea in order to preclude duplication of efforts; identifying information gaps; developing research strategies and Requests for Proposals; recommending priorities for funding of approved contract proposals; and assuring timely transitions to development of mature technologies.

TRANSITION MANAGEMENT

The medical research and development process yields both information and materiel products as illustrated in Figure I-1. Information products generally transition directly from the technology base (6.1, 6.2, 6.3A) to the user community. Materiel products, on the other hand, require extensive investment in development prior to fielding. Because of this added investment for development, a more intense management process is required. The transition process, which involves the partnership among the RADs and the lab commanders, is depicted in Figure V-7. As illustrated, candidate products flow from the laboratories, through a decision point (Milestone 0), to the program manager.

The measure of success for any R&D management system is in the transition of useful, affordable products into the acquisition system and to the user. The system should promote identification of those candidates with the lowest possible technical risk, and lowest possible development and production cost/time; it should promote the balance of these factors against operational requirements identified by the user. Every aspect of the R&D management process should be tempered by the obligation to apply government resources in the manner which promises to yield the maximum benefit in terms of mission capability for the minimum investment of resources.

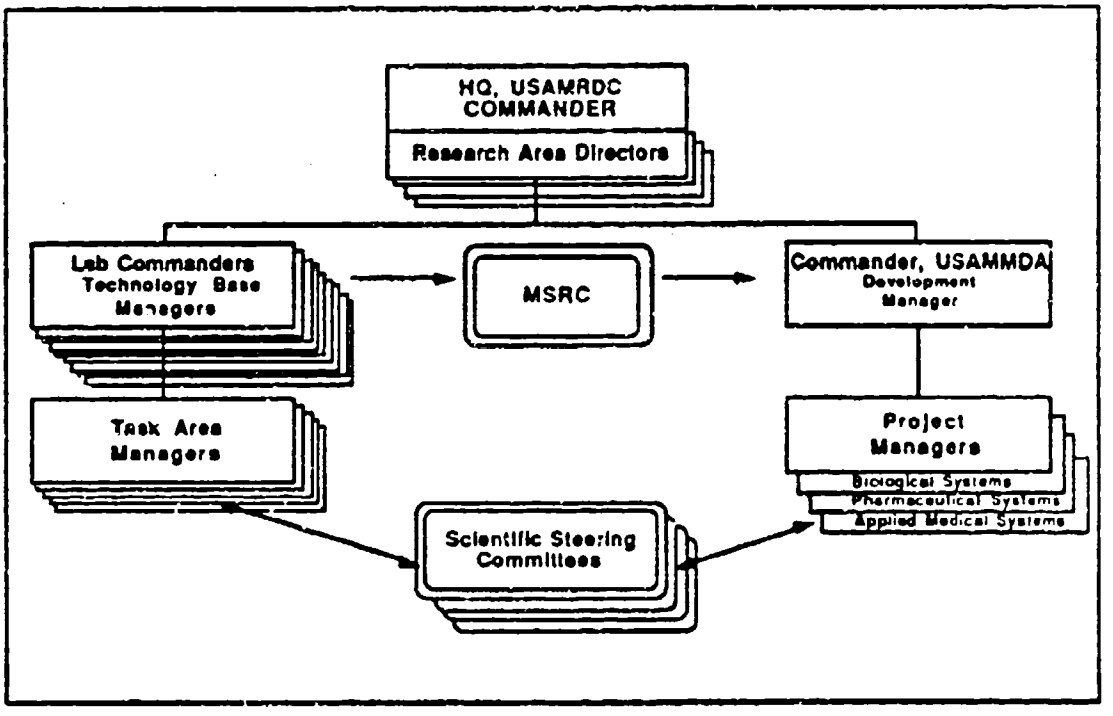


Figure V-7. Transition Management of Medical Products

Technology "Push" versus Requirements "Pull"

The concepts of technology push and requirements pull are related to the influence of supply (technology push) and demand (requirements pull) in shaping research and development programs. Technology push is generated by what is technologically feasible and by the eagerness of the R&D community to identify potential applications and to sell them to potential users; requirements pull is generated by needs and taskings defined by the user community.

The formal structure of the military R&D management system is primarily requirements-based: functional managers (e.g., program managers) select technologies and design systems to meet needs identified by the user (i.e., combat developer). This system is biased toward a requirements pull approach to R&D management, rather than toward one in which researchers identify technological applications and push them on the user. The system is designed to minimize expenditure of resources on technological efforts irrelevant to military applications (i.e., unneeded push); its effectiveness, however, depends on the ability of technologically sophisticated managers/system designers to choose wisely among "off-the-shelf" and novel solutions to military problems.

To be effective, R&D management systems must provide mechanisms for managing push and pull or fail to provide affordable, workable solutions to military needs. If the technology experts are isolated from the needs of the user, their inventiveness can be wasted in pushing technological applications which are not appropriate or even needed, no matter how elegant or state-of-the-art these applications seem to the scientific community. If the program manager and user are isolated from the latest technology or are ill equipped to evaluate its potential application, the development risks are increased and/or the potential military benefits may be lost.

The management challenge is to structure a system in which effective lines of communication are maintained and difficult choices wisely made -- a system which balances push and pull. Through a dialogue in which the program manager is a spokesman for demand and the researcher for supply, a sound compromise between what is desirable to have and what is possible to get can be reached. Within the management structure of medical R&D, it is the responsibility of the RADs to facilitate this dialogue and to "force choices."

In summary, the abilities to effectively identify military requirements, to design militarily useful and technologically superior solutions, and to rapidly transition R&D results into operational benefits is enhanced by the effective use of managers and decision makers who are both technically and militarily qualified. The USAMRDC is unique among military R&D organizations in the large number of uniformed scientists and managers it utilizes. Most of its laboratories are managed by military, rather than civilian, personnel. The integration of military knowledge and sense of mission with scientific expertise has proven valuable in focusing the Command's R&D programs into areas in which there are uniquely military needs. The availability of technically competent military managers throughout the military medical R&D system has proven useful toward the goal of ensuring that the most recent scientific knowledge and technical capabilities are translated into usable products -- both for military health care deliverers and for the soldier. Figure V-8 summarizes some of the many reasons that uniformed scientists are important in the military R&D process.

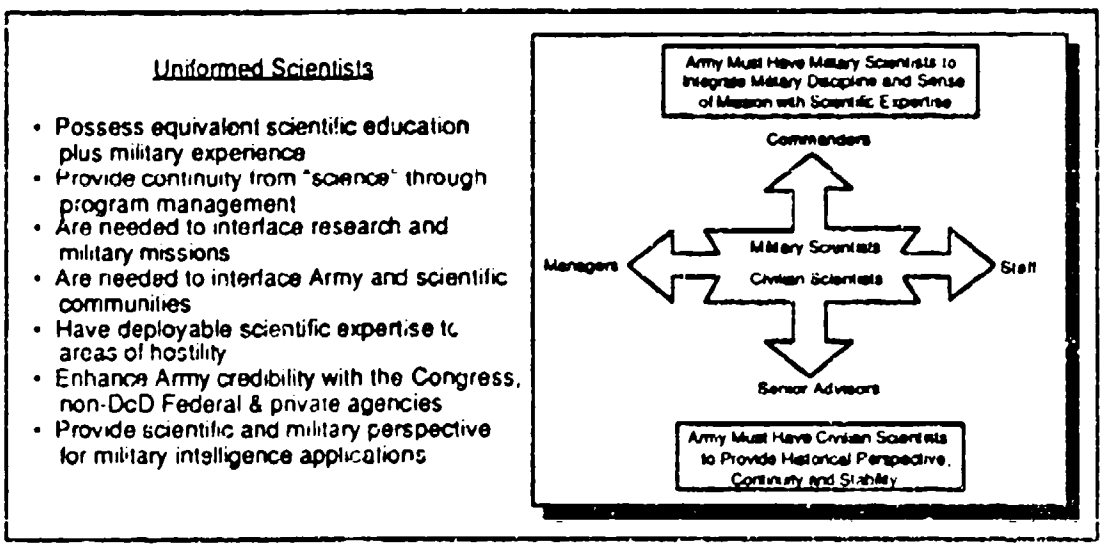


Figure V-8. Requirements for Uniformed Scientists

In addition to management expertise, uniformed biomedical scientists also provide the Army with a deployable problem solving capability unmatched in either the civilian or Federal sectors. Uniformed scientists of the AMEDD have often been called upon to solve problems in the field in both war and peace, from the foxhole to health care facilities worldwide. A recent example is seen in the deployment, within 24 hours of notification, of 15 physicians, nurses, and medical technicians and more than seven tons of supplies and equipment from the U.S. Army Institute of Surgical Research to the Ural Mountains of the Soviet Union. President Bush had offered American medical assistance to the Soviets in the aftermath of the Ural gas line explosion and train wreck. Only the USAMRDC stood ready to respond on

short notice. The fact that this clinically-based research unit, a Table of Distribution and Allowances (TDA) organization, could deploy at all was a surprise to many, but to the USAMRDC it was merely another in a long history of problem-solving missions in the field for uniformed biomedical scientists.

Forcing Choices

Because fiscal constraint is likely to prevail during the next several budget cycles, it will be more important than ever to manage R&D programs efficiently. Unnecessary duplication of effort should be minimized, both in the civilian and military sectors. Research efforts should be focused on the most important requirements, and the most promising candidate solutions should be identified at an early stage in the R&D process. Fewer alternative lines of investigation should be selected at each stage of the R&D cycle. The challenge to management will be to maintain an acceptable balance between risk and potential benefit in an austere fiscal environment.

The challenge of reducing overlap with civilian programs is nothing new to the USAMRDC. Throughout its history, military medical R&D has been required to explain its apparent similarities to national biomedical research programs. Although such overlap appears to occur, seeming similarities rapidly disappear under close examination. Figure V-9 summarizes some of the more important differences between military and civilian biomedical research programs.

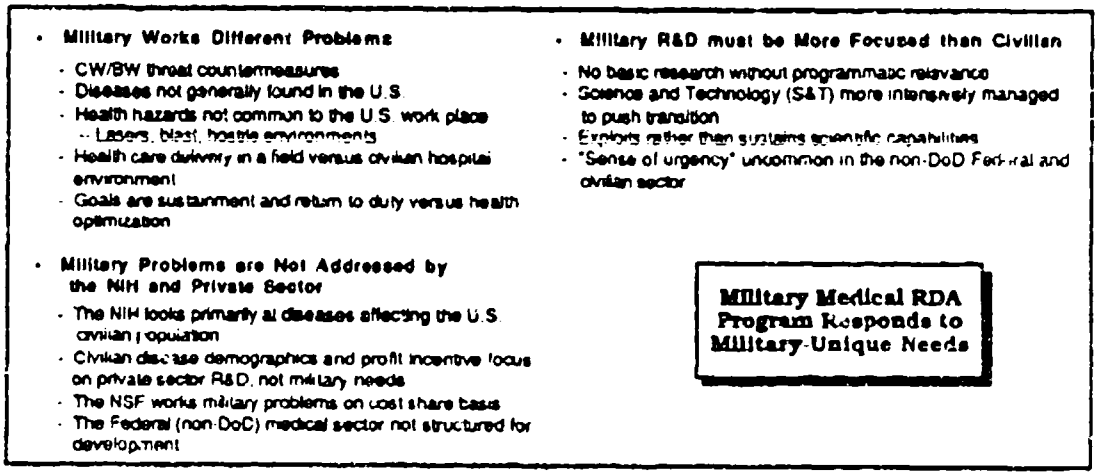


Figure V-9. Military versus Civilian Medical R&D

One of the primary differences between medical and other military R&D is seen in management of basic research programs. In contrast to the "seed money" approach of other military development agencies, the USAMRDC invests relatively little of its 6.1 dollars in the development of new technology and knowledge. In light of the large investment that the civilian sector makes to sustain the basic biomedical sciences, the USAMRDC, historically has invested in 6.1 research which is programmatically unique to military concerns. In the case of military medical R&D, the USAMRDC exploits, rather than sustains, civilian medical R&D for military needs. However, more than ever before, given the funding forecasts for military R&D and the increasing demands that future doctrine places on military medical R&D the USAMRDC needs to increase its surveillance of the civilian biomedical communities' investment patterns, and to adjust its investment strategy accordingly.

The future calls for more intensive management of the military medical technology base toward forcing choices among the competing requirements and candidate solutions. At each stage of the technology base, from 6.1 through 6.3A, scientific managers must work closely with research scientists to identify early the most promising avenues of investigation. Procedures for selection among competing alternatives should be utilized. For instance, early decisions on whether prophylaxes and therapy are both affordable should be made, and the decisions should be based on both military operational factors and technical grounds. The tendency of the best scientists to want to continue product improvement should be tempered by a process which identifies when "good enough is good enough."

Management must balance push and pull and must force choices. Several mechanisms are presently in use within the USAMRDC to optimize this balance: work breakdown structures/work sequences; decision networks or decision trees; rigorous protocol approval processes; review and analysis meetings; workshops; Front-End Analyses; and the formalization of pass/fail criteria, transition decision criteria, and transition review analysis format. In overview, these mechanisms provide an objective, stable, and reliable basis for focusing down the number of R&D candidates, speeding transitions to development, and facilitating communication among the researcher, developer, manager, and user. Several of these mechanisms are described below.

Work Breakdown Structure (WBS)

Once a goal has been established, a WBS is constructed. A list of tasks incorporating sequence relationships from 6.1 to fielding is created for specific research areas. Detail can vary with intended use: more detail for a single product, less for a program plan. The purpose of a WBS is to provide a common framework and language for program planning, a map for management and progress reviews, and a checklist to refer to. Management and coordination of a focused and kinetic research program requires execution of a planned sequence of projects directed toward the identification and development of countermeasures, and regular evaluation of progress to determine which product concepts show greatest promise. A WBS is not intended to restrict research efforts to product development issues. It should also allow for programmatic decisions to investigate potentially important new research technologies. An example of a WBS for the USAMRDC Anticyanide Research Program is shown in Figure V-10.

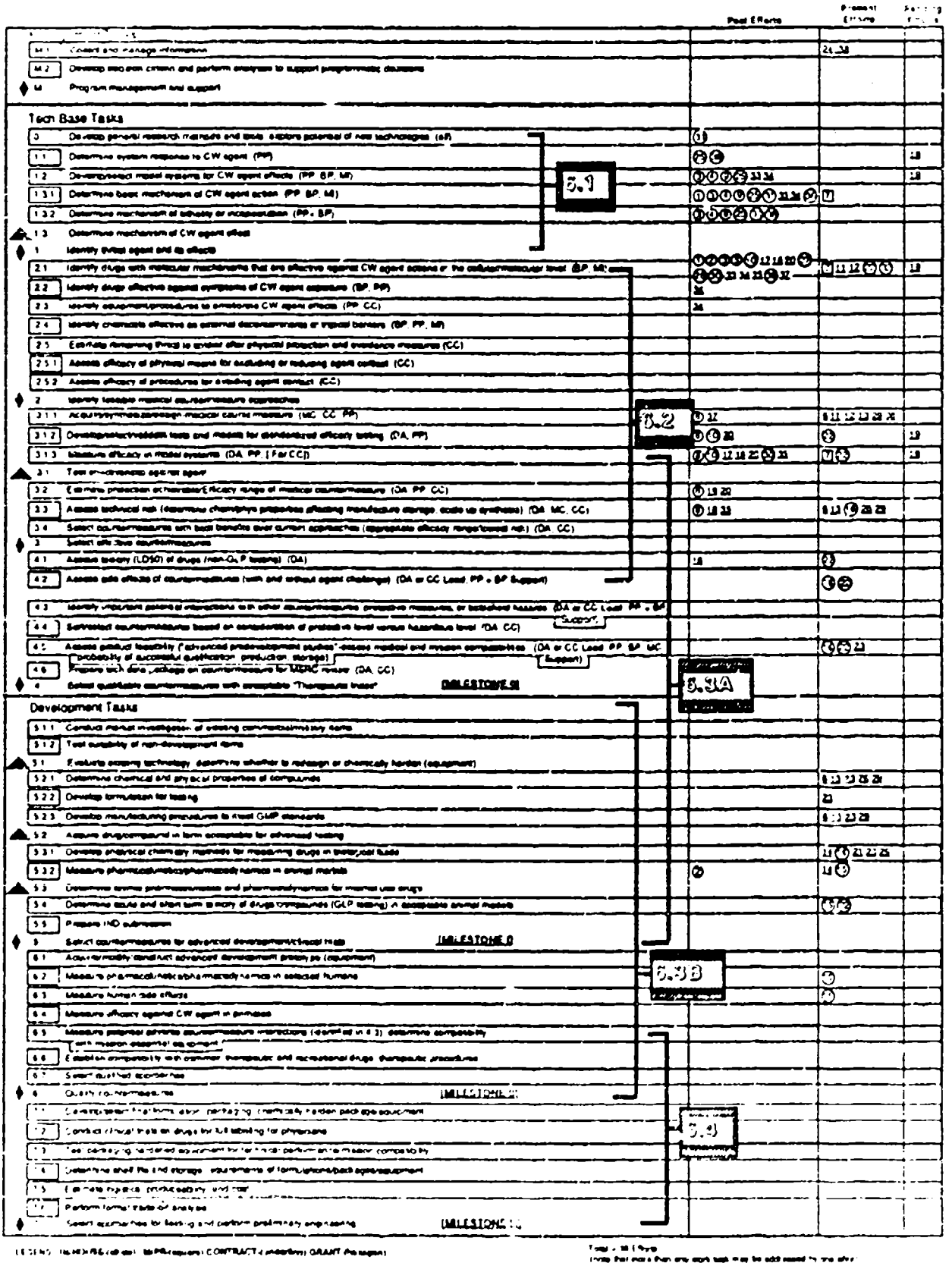
Decision Networks

Another tool utilized by the research manager is the decision network or decision tree. Decision networks provide formalized criteria for efficient pass/fail assessments and standardized data for comparisons and regulatory documentation. By detailing parallel tasks, a decision network provides for an optimum progress rate and the conservation of resources. However, research managers should be cognizant of the assumptions and limitations inherent in this process and guard against rigid adherence to a decision model. Figure V-11 shows an example of a decision network regarding drug screening.

Medical Systems Review Committee (MSRC)

In order to maintain the U.S. technological advantage through rapid transition of new scientific knowledge and technology into militarily useful products, the final transition decisions should not be left solely in the hands of either program managers or scientists. The MSRC provides the formal forum for the necessary coordination, information sharing and decision making.

Membership of the MSRC is drawn from USAMMDA Project Managers (PMs), RADs, and Laboratory Commanders. (Specific attendance at meetings varies according to the product(s) being considered.) Meetings are scheduled, coordinated, and chaired by the Commander, USAMMDA. The approval authority for any MSRC action is the Commander, USAMRDC.



5-13 Figure V-10. Example of a Work Breakdown Structure: Anticyanide Research Program

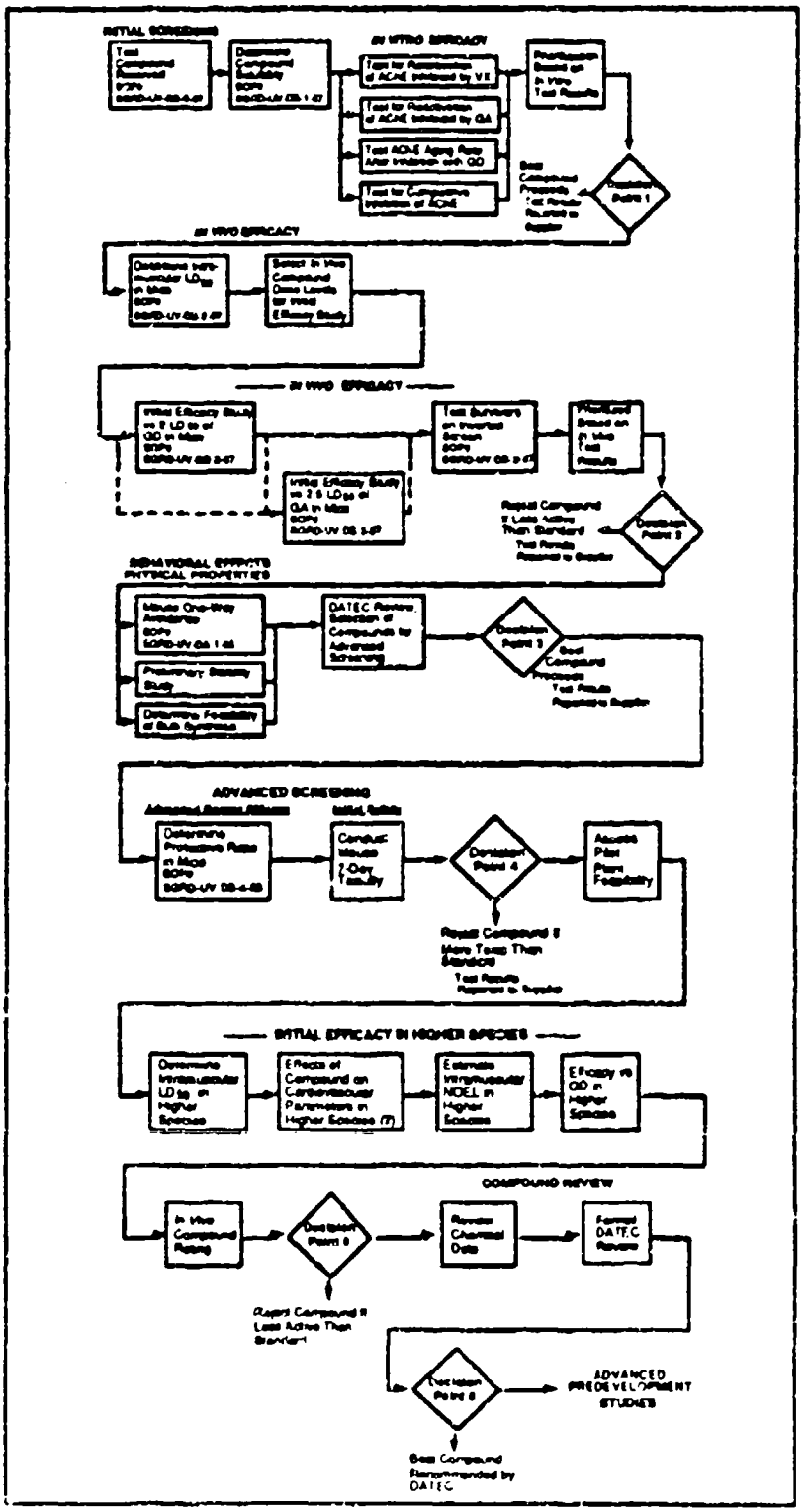


Figure V-11 Drug (Oxime) Screen Decision Network

The MSRC is the formal mechanism to assure technology maturity for Milestone 0 transition decision. The committee convenes as needed or at least once a year to review and recommend technology base items or projects for transition to development (6.3B). The MSRC provides the basis for integrating, structuring, and defining workloads and actions required to support timely Program Initiation decisions. The committee's primary goal is to optimize transition points in a project while reducing development risk. When sufficient data addressing critical issues has been obtained, and important technology base questions have been answered, a transition point is determined. Figure V-12 shows MSRC's role in R&D program management.

The committee also considers and recommends the return of products to the technology base due to issues that cannot be resolved in the development phase, and MAMP-joint conference recommendations to modify or abort a product development program. Candidates for return to the technology base are identified by the appropriate Program Manager with rationale for its return and the issues which must be satisfactorily resolved prior to renomination for transition. Among reasons for deletion of a product, presented by the Commander, USAMMDA, are: change in threat, catastrophic test failure, lack of progress toward meeting performance requirements, excessive cost of meeting performance requirements, and failure to meet regulatory requirements.

Candidate products for transition from technology base to development are usually nominated by the appropriate Laboratory Commander. However, any MSRC member prepared to justify his nomination can nominate products for MSRC consideration. Criteria for nominating products for MSRC review varies by category (e.g., pharmaceuticals, biologicals, and applied medical systems). Nominations are made for transition to the USAMMDA only after appropriate selection criteria have been satisfied.

Usually, products recommended for transition to development are briefed to the MSRC by the Laboratory Commander responsible for that product in the technology base or by the Commander's technical expert. Presentations have a required format. Although each MSRC member plays a vital role in the process, for each product under consideration, only the lead PM, the responsible RAD, and the performing Laboratory Commander(s) may vote. In the event of a tie, the Chairman casts the deciding vote.

The minutes of the MSRC meeting, including specific recommendations, are forwarded to the Commander, USAMRDC, for approval and become part of the Program Management Documentation for each item considered by the MSRC. Appropriate technical, management, and fiscal documentation is transferred to the USAMMDA with the products approved for transition to development.

Scientific Steering Committees

The tendency of scientists to want to improve upon their scientific and intellectual products should be balanced against the need to develop products according to constrained cost, schedule, and performance guidelines, and other regulatory requirements. Although it is essential that PMs maintain control over the development process, it would be counterproductive to isolate the PM from the very expertise which made the product being managed a reality. For this reason, scientific steering committees are used to provide the continuing dialogue between PM and scientist so essential to successful development and fielding. These committees also ensure that the DoD and Army objective of inserting the latest advances in technology into developing systems is considered at each stage of the development process.

Scientific steering committees also fulfill other purposes throughout the R&D cycle from 6.1 to 6.4. Figure V-13 describes several examples of how these committees can provide mechanisms for interdisciplinary scientific and management review. The Drug Assessment Technical Evaluation Committee depicted in the figure is a prime example of a committee which facilitates the transition process.

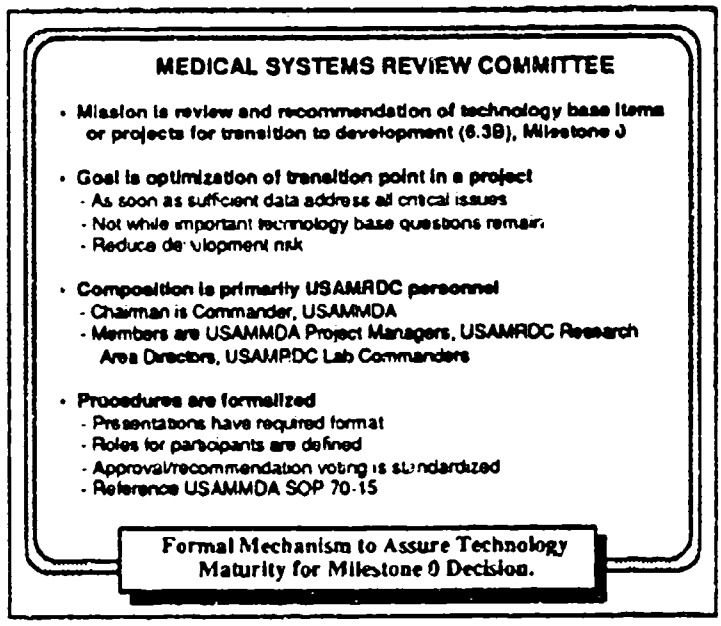


Figure V-12. MSRC's Role in R&D Program Management

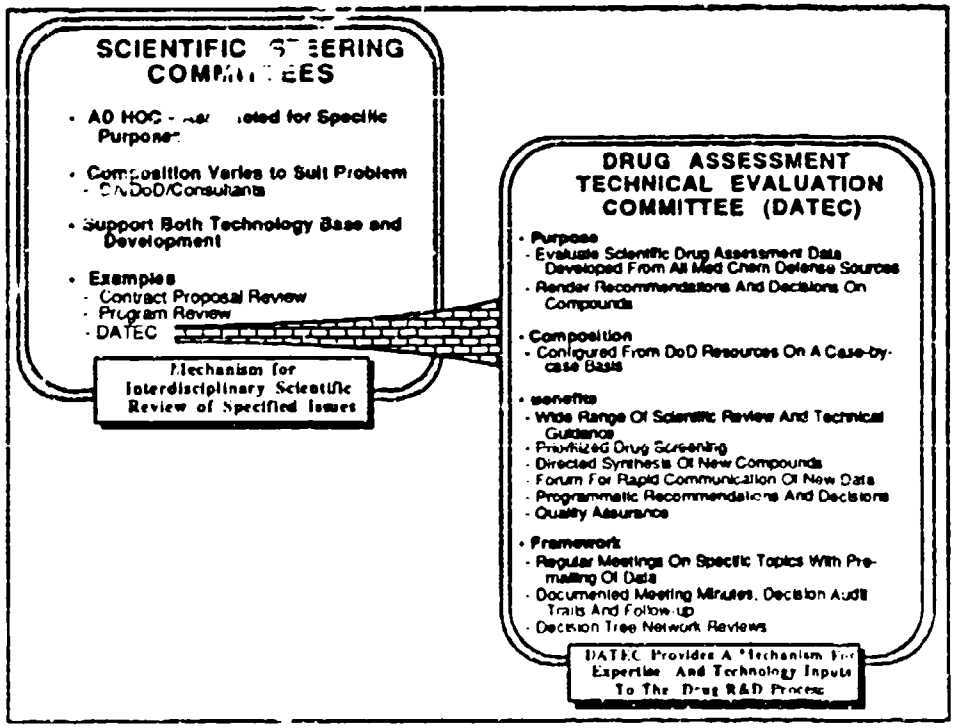


Figure V-13. Scientific Steering Committee Utilization

SUMMARY

This chapter has reviewed some of the management policies, procedures, and mechanisms important to the fielding of operationally useful products in a timely and cost-effective manner. Of particular importance to this process is the matrix management mechanism involving dialogue and coordination among scientists and managers, RADs and Commanders, and the various staff elements throughout the DoD. The successful operation of this system of overlapping responsibilities is assured by effective communication and a willingness to adhere to the motto of the USAMRDC -- "Research for the Soldier."

Section VI

MEDICAL R&D PROGRAM AREAS

INTRODUCTION

The USAMRDC plans, programs, and executes programs to sustain the operational capabilities required to foster and exploit technological advances. The technology, technological information, and medical materiel obtained through these programs are applied to counter chemical and biological threats, reduce the historically high incidence of infectious diseases, minimize the impact of military systems health hazards, decrease the effects of combat stress, lessen the effects of environmental extremes, and improve casualty evacuation, treatment, and survivability. The USAMRDC's medical research and development programs encompass the following research areas: military disease hazards (infectious disease, medical biological defense, AIDS research); combat casualty care; systems hazards; and medical chemical defense.

The Army's Technology Base Master Plan contains the Technology Base Investment Strategy for meeting the needs envisioned by the Army leadership. The Medical Technology Base Master Plan outlines the Army medical requirements within each program area and guidance (e.g., BDP and AMEDD Capability Issues, Army STOs) for approaching these issues as well as the strategies for solutions proposed by the USAMRDC. For each of the research areas, this section: 1) presents the current mission, goals, and objectives; 2) identifies the primary DoD laboratories associated with the research and their areas of interest; 3) presents the requirements and guidance to be addressed; 4) enumerates the threats, countermeasures, and technical barriers to those countermeasures; and 5) projects budgets through FY96. Following the discussion of the research program areas is a description of the technical barriers faced by the program areas and the research needed to address these barriers. This section concludes with a generic discussion of future directions which encompasses a long-range vision of those medical requirements where the USAMRDC can contribute to conserve the fighting strength of our soldiers and simultaneously meet our country's strategic objectives for the year 2010. This future direction is adapted from the ATBMP and the Health Services Long-Range Plan, which is part of the ALRPS; the ALRPG; and other special and functional long-range plans.

DRIVERS OF THE CURRENT PROGRAM

The USAMRDC manages and executes a worldwide research and development program aimed at solving medical problems of importance to national defense. The technology base program is directed toward threats as they are identified and guided by documents referred to above. The foundation of the USAMRDC's current program is the Army STOs. A STO is a requirement for establishing the technology needed to develop a specific information item or family of materiel. STOs provide Army guidance to the technology base community and are addressed by Basic Research (6.1), Exploratory Development (6.2), and Non-Systems Advanced Development programs (6.3.A). The STOs are generated in direct response to the deficiencies and corrective actions identified by the BDP and AMEDD Capability Issues (see Section III for a description). Together, they serve as a guide for technology base prioritization processes. The STOs as they appear in Annex A, Army Tech Base Master Plan, Volume II, are listed in Figure VI-1. The AMEDD CIs are listed in priority in Figure VI-2. The matrices that follow in Figures VI-3 through VI-5 link the Army STOs and BDP and AMEDD CIs with the USAMRDC's research program areas.

I. Mission Area Technology and ATTD Objectives

C. Combat Service Support

II.I.5 Demonstrate safety and efficacy sufficient for a FY91 Milestone 0 transition of technology for a topical protectant against classical warfare agents.

II.I.10 Complete the pathophysiology database on vesicant agents prior to FY92; exploit these data prior to FY94 for definitive medical care and treatment strategies which will hasten return-to-duty.

II.I.11 Demonstrate by FY92 the safety and efficacy of a medical pretreatment effective against potential cyanide threat agents.

II.I.12 Demonstrate by FY96 safety and efficacy sufficient for a Milestone 0 transition of technology for an advanced anticonvulsant adjunct or component for the soldier/buddy-use nerve agent antidote.

II.I.13 Demonstrate by FY93 safety and efficacy data sufficient to establish the technological feasibility of an advanced *first-viral* drug which is effective against an expanded range of viral threat agents.

II.I.14 Provide by FY93 sufficient technical data to support transition to development of simple field kits with the capability to rapidly identify the biological hazards to U.S. Forces in specific geographic areas of high military interest.

II.I.15 Describe the effects and identify the mechanisms of action of laser and microwave directed energy. Complete by FY95 studies of the impact of microwave radiation on soldier performance and provide by FY97 technology for eye protection effect against frequency agile laser sources.

II.I.16 Provide by FY93 sufficient technical data to support transition to development of biodegradable bone repair material.

II.I.17 Provide by FY96 sufficient technical data to support transition to development of improved head injury therapies.

II.I.18 Provide by FY93 safety and efficacy data sufficient to support transition to development of a vaccine effective against malaria (*Plasmodium falciparum, merozoite*).

II.I.19 Provide by FY98 sufficient technical data to support transition to development of a vaccine or anti-toxin effective against multiple presynaptic neurotoxins.

II.I.20 Provide by FY98 sufficient technical data to support transition to development of a vaccine effective against Typhus (Typhus group).

II. Key Emerging Technologies

E. Biotechnology

II.E.5 Rapid Wound Healing. By FY95 develop improved methods of providing skin substitutes and other products to accelerate wound healing, thereby minimizing lost duty time.

II.E.6 Blood Substitutes. By FY96 develop techniques to permit the development of non-refrigerated blood substitutes for use in a battlefield setting. This will minimize the convalescent period and expedites soldiers' return to duty.

II.E.7 Chemical Agent Prophylaxes. Establish feasibility of monoclonal antibody technology for prophylaxes against multiple LD50 exposures to G and V nerve agents by FY94. Evaluate the feasibility of vaccine protection against these agents by FY96.

II.E.8 Bioengineered Vaccines. Establish by FY92 the technological feasibility of developing single bio-engineered vaccines which are producible, affordable, and safe as well as effective against an entire class of viral agents, whether of natural or threat origin (polyvalent, vectored vaccines).

J. Neuroscience Technology

II.J.1 Psychiatric Support. In support of technologies to identify, prevent or treat combat psychiatric casualties, by FY92 provide techniques for reducing degradation of decision making and performance resulting from sleep loss; by FY95 develop sufficient information to support new doctrine for prevention and management of combat psychiatric casualties and by FY96 identify candidate compounds for pharmacological intervention.

II.J.2 Validation and Extrapolation of Test Results to Man. Conduct an enhanced research program on the extrapolation of research results from animal to man and from the laboratory to the field. Identify by FY95 the model systems, procedures and assessment technology to improve the accuracy of laboratory tests in predicting battlefield performance.

II.J.3 Reduction of Biological and Pharmaceutical Pretreatments Side Effects. By FY96 conduct fundamental studies on the interaction of endogenous bioregulators and exogenous chemicals and other neuromodulators on mental and physical performance; establish the feasibility of concepts for dramatically reducing or eliminating the potentially debilitating side effects of biologicals and pharmaceuticals (e.g., CB pretreatments and antidotes, anti-malarial drugs).

II.J.4 Neural Receptors. By FY98 identify and define the functional and molecular characteristics of neural receptors and evaluate these receptors as models for inclusion in identification and detection applications.

II.J.5 Neuro Behavioral Data Base. Provide by FY92 the neuro-behavioral database required to provide more accurate estimates of individual and unit performance decrements in environments contaminated by low to moderate levels of classical chemical threat agents. Expand the research effort to classical biological threat agents and emerging threats of either chemical or biological origin.

III. Systemic Issues

D. Soldier Oriented R&D (SORD)

III.D.12 By FY91 identify those biomedical technologies and procedures which have special promise for application in the reduction of morbidity and mortality of battlefield casualties under the constraints imposed by AirLand Battle Future and Army 21; develop comprehensive management and execution plans and programs sufficient to establish a Center of Excellence for Combat Casualty Care which has the specified mission of evaluating these technologies and procedures under laboratory and clinical conditions.

III.D.13 Provide by FY94 technologies to support identification of category, wound type, and extent of injury to facilitate medical support and definitive care throughout the evacuation chain.

III.D.14 Demonstrate by FY93 the technology to conduct rapid field identification of drug resistance patterns in human pathogens.

III.D.15 In support of injury prevention and maximization of soldier performance under conditions of environmental extremes, evaluate by FY92 the nutritional effectiveness of new heat loading systems under conditions of environmental extremes; by FY93 handoff technologies for improved prediction of heat casualties and by FY94 identify improved pharmacologic methods for reducing acute mountain sickness.

IV. Supporting Technologies

B. Test and Evaluation Technology

IV.B.1 Determine environmental and health effects criteria levels for military unique toxic wastes generated by past activities, before FY93. Develop data bases and conduct health and environmental toxicity assessments of the current generation of propellants, explosives and effluents by FY94. Provide non-mammalian toxicity models in order to reduce use of animals in testing before FY94.

C. Simulation and Modeling

IV.C.1 By FY92 develop a long-range plan to provide technologies which will reduce reliance on animal and human subjects research; such technologies will reduce ADT&E vulnerability to geographical constraints while lowering research costs.

D. Assessment Technology

IV.D.2 Conduct an enhanced research program in risk assessment methodology which is directly applicable to establishment of operational (battlefield) health risk criteria, as well as occupational health risk criteria. Identify by FY94 the model systems, procedures and risk assessment methodology necessary to facilitate the establishment and improve the accuracy of scenario dependent CB hazard risks criteria for use by field commanders.

Figure VI-1. Army Science and Technology Objectives

1. Inadequate Resuscitation Management System
2. Inadequate Capability to Assess, Prevent and Treat Environmental Health Threats
3. Inadequate Blood (Oxygen Carrying) Substitutes
4. Inadequate Medical/Surgical Treatment Capability for Battlefield Wounds
5. Inadequate Capability for Medical Units to Keep up with Support Units
6. Inadequate Vision Correction/Protection for Battlefield Requirements
7. Inadequate Chemical Agent Prophylaxis, Pretreatments, Antidotes and Therapeutics
8. Inadequate Capability for Diagnosis, Treatment and Prevention of Combat Stress and Neuropsychiatric Disorders
9. Inadequate Capability of Soldiers to Perform Self/Buddy Aid
10. Inadequate Capability of Medical Units to Identify Disease Agents
11. Inadequate Medical Evacuation Platform Hardening Against NBC Agents
12. Inadequate Medical Evacuation Platform Mobility, Capability and Survivability
13. Inadequate Biological Agent Prophylaxis, Pretreatments, Antidotes and Therapeutics
14. Inadequate Combat Zone and Communications Zone Medical Assets for Battlefield Requirements
15. Inadequate Capability to Decontaminate Wounded/Injured Patients
16. Inadequate Material Handling Equipment for Medical Units
17. Inadequate Medical Resupply Support
18. Inadequate Refrigeration/Freezer Capability in Medical Organizations
19. Inadequate Protection of Medical Materiel from Environment and NBC Agents
20. Inadequate Medical Personnel Performance of Treatment Tasks and Field Medical Equipment Operation
22. Inadequate Treatment Regimens for Directed Energy Injuries
23. Enhance Medical Support by Using Existing Space-Systems
24. Inadequate Medical Command, Control and Communications System
25. Inadequate Recognition, Monitoring and Correction of Health Hazards
26. Inadequate Dental Treatment Leads to Preventable Dental Casualties
27. Inadequate Number of Medical Evacuation Platforms
28. Inadequate Radiological Prophylaxis, Pretreatments, Antidotes and Therapeutics
29. Inadequate Capability of Medical Personnel to Perform Duties in MOPP
30. Inadequate Decontaminants for Medical Supplies and Equipment
31. Inadequate Field Kitchen System to Provide Medical Food Service in the Theater
32. Inadequate Power Distribution and Lighting Systems in Medical Units
33. Inadequate Capability of Medical Units to Identify and Quantify NBC Agents
34. Inadequate Test Measurement and Diagnostic Equipment for Medical Equipment
35. Inadequate Field Medical Record System for Integrated Battlefield
36. Inadequate Medical Intelligence Assets to Acquire Disease and NBC Information
37. Inadequate Command, Control and Communication of Medical Regulations
38. Inadequate Medical Food Service Support in Theater Hospitals
39. Inadequate Optometry Support in Theater of Operations
40. Inadequate Veterinary Support for Total DoD Mobilization
41. Inadequate Configuration of Preventive Medicine Organizations to Deploy and Function
42. Inadequate Identification of Medical Personnel with Specialized Skills
43. Inadequate Plans for Converting Civilian Facilities to Hospitals
44. Inadequate Linguistic Resources Available within the AMEDD
45. Inadequate Dental Hygiene Support at General Hospitals and Convalescent Centers
46. Inadequate Veterinary Support of Military Working Dogs (MWD)

Figure VI-2. AMEDD Capability Issues

	I				II					I							V					III					
	Infectious Disease				Combat Casualty					Biological Defense							Chemical Defense					Systems Hazards					
STOs	Bacterial	Viral	Parasitic	Other	Resuscitation	Wound Heal	Med Support	Surgical Res	Other	Viral	Neurotoxin	Hepatotoxin	Protein Inhib	Mem Act Tox	Phys Act Com	Other	Nerve	Blister	Emerging	Blood	Other	Environment	Psychological	Toxic	Biomechanical	Directed Energy	Other
Modernization Plan																											
I.I.5																	X	X			X						
I.I.10																		X									
I.I.11																				X							
I.I.12																	X				X						
I.I.13		X								X																	
I.I.14	X	X	X							X	X	X	X	X	X												
I.I.15						X																				X	
I.I.16						X		X																			
I.I.17					X	X	X	X																			
I.I.18			X																								
I.I.19											X																
I.I.20				X																							
Emerging Technologies																											
II.E.5					X	X	X	X																			
II.E.6					X		X	X																			
II.E.7																	X										
II.E.8		X								X																	
II.J.1									X														X				
II.J.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
II.J.3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X
II.J.4				X							X				X	X								X			X
II.J.5										X	X	X	X	X	X	X	X	X	X	X	X						
Systemic Issues																											
III.D.12					X	X	X	X	X																		
III.D.13					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
III.D.14	X	X	X	X						X						X											
III.D.15																											X
Supporting Technologies																											
IV.C.1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
IV.D.2	X	X	X	X						X	X	X	X	X	X	X	X	X	X	X	X	X		X			X
IV.P.1																								X			

Figure VI-3. Research Program Areas versus STOs

CIs	Infectious Disease	Combat Casualty	Biological Defense	Chemical Defense	Systems Hazards
1		X			
2	X		X	X	X
3		X			
4		X			
5		X			
6					X
7				X	
8					X
9				X	
10	X		X		
11	Non Medical R&D				
12	Non Medical R&D				
13	X		X		
14	Non R&D Solution				
15				X	
16	Non R&D Solution				
17		X			
18		X			
19	Non Medical R&D				
20	Non R&D Solution				
22		X			X
23	X				X
24	Non Medical R&D				
25					X
26		X			
27	Non R&D Solution				
28	AFRRI Lead				
29			X	X	X
30	Non Medical R&D				
31	Non Medical R&D				
32		X			
33			X		
34-45	Non Medical R&D				
46	X		X	X	X

Figure VI-4. Research Program Areas versus AMEDD Capability Issues

	BDPs												
	17	31	33	44	45	51	53	57	71	73	77	83	97	117
Infectious Disease				X			X							
Combat Casualty		X										X	X	
Biological Defense	X	X			X		X	X						X
Chemical Defense	X	X			X		X	X						
Systems Hazards	X	X	X			X	X		X	X	X		X	X

Figure VI-5. BDP Capability Issues versus Research Program Areas

AFRRI Armed Forces Radiobiology Research Institute

CURRENT PROGRAMS

The current USAMRDC program encompasses areas of research directed to the preservation of manpower through the development of medical knowledge, vaccines, drugs, and equipment in order to: prevent and treat infectious diseases, protect from hazardous environments (including exposure to chemical and biological agents), enhance military performance, and achieve recovery from combat wounds.

MILITARY DISEASE HAZARDS

The Military Disease Hazards Research Program consists of basic and applied studies related to prevention, diagnosis, and treatment of infectious diseases of concern during mobilization and deployment; it includes medical defense against biological agents. In addition, a separate research area addresses the military impact of AIDS.

Infectious Disease

Mission, Goals, and Objectives. The mission of the Infectious Disease Research Program area is to preserve soldier manpower and performance by the prevention and treatment of infectious diseases that occur naturally worldwide. The USAMRDC is the Congressionally assigned lead agency for infectious diseases of military significance [HR Report 97333, DoD Appropriation Bill, 1982 Report of the Committee on Appropriations, page 247]. The goal of the program is effective disease prevention to enable deployment and sustain warfighting capability or, at least, to return personnel to duty before they are required to be evacuated from the division area.

Research into naturally occurring infectious diseases is primarily related to the prevention and, to a lesser extent, the treatment and diagnosis of infectious diseases that could seriously hamper military mobilization, deployment, and capability. The objective of the research is to prevent incapacitation of troops due to disease by reducing the severity and duration of infectious disease, and maximizing return-to-duty in forward areas.

The numerous accomplishments under the Infectious Disease Research Program appear in Section II in a comprehensive medical defense timeline citing contributions of military medicine. Disease is one of the primary causes of lost duty time in both war and peace.

Infectious disease threats have an impact on units, are a major cause of hospital admissions, increase the requirement for replacements, increase recycles in basic and advanced individual training, and threaten mobilization, training and deployment. Basic threat categories include bacteria, viruses, and parasites.

The Infectious Disease Research Program encompasses the following studies:

- Basic studies applicable to development of vaccines against militarily important diseases, including assessment of safety, immunogenicity and efficacy
- Studies directed to the discovery and development of prophylactic and treatment drugs for infectious diseases, including drug design, synthesis, screening, mode of action, and mechanism of drug resistance
- Collection and analysis of epidemiological data that aid in control of relevant infectious diseases
- Studies of control measures against infectious disease vectors, including arthropod repellents, vector competence, biosystematics, detection of infected insects, and vector control techniques and equipment, including new pesticide formulations and pesticide formulation technology
- Development of treatment for infectious diseases, including studies to synthesize, screen, and develop therapeutic drugs for malaria

Primary DoD Participating Laboratories. The primary DoD laboratories participating in the Infectious Disease Research Program and their areas of research are: Walter Reed Army Institute of Research, Principal Laboratory (viruses, parasitic diseases, bacteria, AIDS); U.S. Army Medical Research Institute of Infectious Diseases (agents requiring containment); Naval Medical Research Institute (rickettsia/bacteria); and the U.S. Army Biomedical Research and Development Laboratory (vector control).

Threats, Countermeasures, and Technical Barriers. The countermeasures and technical barriers to their implementation that are associated with the broad threat areas addressed by the Infectious Disease Research Program are identified below. Annex D includes a table of the geographical distribution of diseases and an elaboration on and a brief history of the diseases of military importance.

Threat Category: Bacterial Disease

Countermeasures:
- Simple field kits for rapid identification of bacteria
- Safe and efficacious antibacterial vaccines
- Therapeutic measures
- Epidemiological studies of militarily significant disease (threat assessment)

Technical Barriers:
- Appropriate model systems for investigation of disease countermeasures
- Rapid bacteria identification technology
- Required pharmacological characteristics of prophylactic drugs
- Production of polyvalent vaccines effective against disease classes
- Expression vectors for recombinant products (vaccines)
- Prevention of drug resistance development
- Immune system enhancement

Threat Category: Viral Disease

Countermeasures:
- Drugs with broad-spectrum antiviral activity
- Simple field kits with the capability to rapidly identify pathogens in humans
- Vaccines bioengineered by strain attenuation and inactivated or synthetic antigens
- Polyvalent vaccines

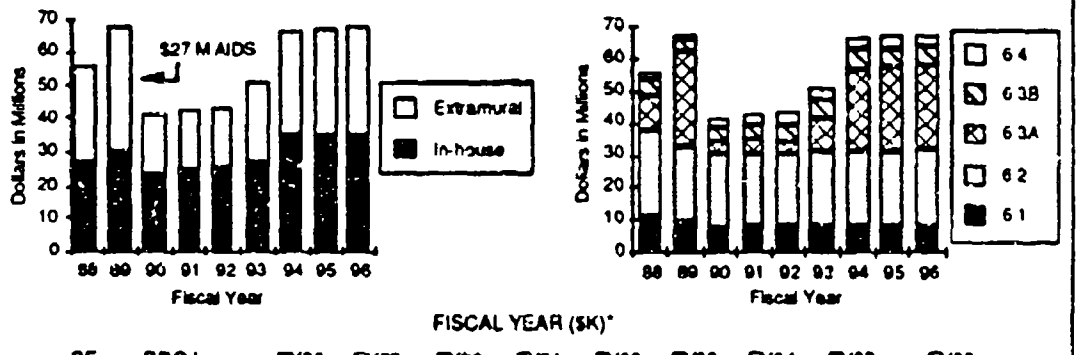
Technical Barriers:
- Appropriate model systems for investigation of disease countermeasures
- Nontoxic antiviral drugs
- Required pharmacological characteristics of prophylactic drugs
- Production of polyvalent vaccines effective against disease classes
- Expression vectors for recombinant products (vaccines)
- Prevention of drug resistance development
- Immune system enhancement
- Rapid virus identification technology

Threat Category: Parasitic Disease

Countermeasures:
- Drugs with specific antiparasitic activity
- Simple field kits with the capability to rapidly identify infected vectors and to diagnose disease
- Vaccines against classical parasitic diseases
- Topical protectants
- Vector control

Technical Barriers:
- Appropriate model systems for investigation of disease countermeasures
- Required pharmacological characteristics of prophylactic drugs
- Prevention of drug resistance technology
- Expression vectors for recombinant products (vaccines)
- Rapid identification technology for infected vectors
- Environmentally sound biological controls for disease vectors

Projected Budgets. Projected budgets for the Infectious Disease Research Program area through FY96 are identified in Figure VI-6. Funding is projected by FY for extramural versus in-house research, technology base categories, program elements and projects, and AIDS research.



FISCAL YEAR ($K)*

PE	PROJ	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96
61102	BS13	11132	9424	7892	7931	8067	8177	8168	8250	8332
62787	3CL + A870	26182	22948	22645	23030	22671	23239	22999	23229	23461
63002	D810	2417	2859	3372	3328	3277	3430	3487	3522	3557
63807	D808	4662	3461	4553	5093	5593	5973	6071	6132	6193
64807	D849	1861	2379	2852	3224	3506	3657	3717	3754	3792
TOTAL		46254	41071	41321	42606	43204	44476	44442	44887	45335
AIDS										
63105	DH29	9365	26683	0	0	0	6196	21908	22127**	22348**
ID + AIDS TOTAL		55619	67754	41321	42606	43204	50672	66350	67014	67683

* Effective circa 25 August 1990, subject to variation FY 90-96
** Subject to DA decision

Figure VI-6. Projected Budgets through FY96 for the Infectious Disease Research Program (Includes Military AIDS Research)

Medical Biological Defense

Mission, Goals, and Objectives. The mission of the Medical Biological Defense Research Program (BDRP) is to develop medical countermeasures to deter, constrain, and defeat the use of biological agents against U.S. Forces [DoD Directive 5160.5, March 30, 1976 (as amended)]

The program is directed against agents of biological origin that are potential military threats. Some potential threat categories are identified in Figure VI-7. A primary concern is the development of prophylactic and therapeutic drugs, vaccines, antitoxins, and toxoids against agents of biological origin (see Figure VI-8). Goals of the program include deterring opposing forces from developing and/or

BACTERIA
- Reproduce by simple division
  - *Bacillus anthracis* - Anthrax
  - *Francisella tularensis* - Tularemia

RICKETTSIA
- Small bacteria that reproduce inside cells
  - *Coxiella burnetti* - Q fever

VIRUSES
- Nucleic acid with a protein coat
- Nucleic acid enters host cell and produces progeny viruses
  - Venezuelan Equine Encephalitis (VEE)
  - Rift Valley Fever (RVF)

TOXINS
- Naturally occurring compounds produced biologically or synthetically that are toxic to other organisms
  - Staphylococcal enterotoxins
  - Botulinum toxin
  - Snake toxin
  - Ricin

PHYSIOLOGICALLY ACTIVE COMPOUNDS
- Biochemicals that occur naturally in the body as regulators of body functions
  - Insulin

ALTERED MICROORGANISMS
- Organisms changed to have new properties
- Decreased/increased disease potential
- Antibiotic resistance
- Extended shelf/field life
- Increased commercial potential

Figure VI-7. Potential Threat Categories

VACCINES
- Broad spectrum - single antigen that protects against many related agents
- Polyvalent - mixture of antigens that protects against a number of different agents
- Vectored - single carrier virus genetically engineered to confer immunity against more than one agent

ANTIBODY
- Homologous - collected from an individual who has protective immunity against the disease
- Human monoclonal - produced by the fusion of a human white blood cell with a tumor cell (myeloma) capable of immortality and producing antibody
- Human mouse monoclonal - produced by immortal white blood cells of human origin with mouse combining sites
- Broad-spectrum antitoxin

DRUGS
- Broad-spectrum antivirals
- Antitoxin drugs

DIAGNOSTIC TECHNOLOGIES
- Field - prevent surprises
- Laboratory - confirm agent used, justify strategic response

Figure VI-8. Medical Biological Defense Countermeasures

employing biological weapons, rapidly returning personnel to duty after they develop symptoms, and preventing fatalities from a biological attack. In addition to requirements derived from Army sources (for example, STOs, BDPs, etc.), the BDRP must respond to requirements of other Services as specified in the JSA (see Appendix D).

The objectives differ with the varying threats:

- Viral threats - Generate data sufficient to establish the potential for second-generation, broad-spectrum antiviral drugs, and establish the technological feasibility of developing vaccines effective against entire classes of viruses
- Neurotoxin threats - Provide sufficient technical data to support transition to development of vaccines, antitoxins, and rapid-identification field kits effective against multiple neurotoxins
- Hepatotoxin, protein-inhibiting toxin, and membrane-active toxin threats - Provide data to support transition of products effective against the threat
- Physiologically active compound (PAC) threats - Conduct studies on the actions of endogenous bioregulators on mental and physical performance

The current Medical Biological Defense Research Program includes the following areas of research:

- Viral and rickettsial studies - Identification and characterization of organisms, molecular antigenic analysis, development of diagnostic assays and investigations of pathogenesis, immunology, and epidemiology that will allow decisions regarding the optimal approach to disease prevention and control
- Bacterial studies - Development of potential toxin-based or spore vaccines, and determination of the role of these vaccines in the cellular and humoral immune response
- Toxin research - Basic and developmental research leading to methods of defense against broad classes of toxins
- Drug development - Development, synthesis, and testing of compounds with antiviral, immunomodulatory, or antitoxin activities, with emphasis on compounds that provide broad, nonspecific protection against viral agents or classes of toxins in the viral bacterial, and toxin domain
- Detection - Investigation and evaluation of sensitive and specific methods for detection of infectious organisms, antigens and antibodies in biological materials to include the application of nucleic acid probes or synthetic antigens development of rapid identification and diagnostic methods for the assay of toxins, metabolites, and analogs in clinical specimens and collector samples
- Computer science and artificial intelligence - Use of computer science and artificial intelligence techniques to enhance fundamental medical systems for biological defense (drugs, vaccines, diagnostic capabilities, management of biologically exposed casualties)

International policies that contributed to shaping the program are shown in Figure VI-9; a synopsis of the recent program history appears in Figure VI-10.

Primary DoD Participating Laboratories. The primary DoD laboratories participating in the Biological Defense Research Program and their areas of research are: the U.S. Army Medical Research Institute of Infectious Diseases, Principal Laboratory (viruses, bacteria, rickettsia, membrane-active toxins, protein-inhibiting toxins, hepatotoxins); Walter Reed Army Institute of Research (staph enterotoxins, PACs); and the U.S. Army Medical Research Institute of Chemical Defense (low-molecular-weight neurotoxins).

1925 Geneva Protocol
Prohibited use of biological and chemical warfare
- USSR ratified protocol in 1928 with reservations; ceases to be binding to enemy states that do not observe provisions
- U.S. ratified protocol 10 April 1975

25 November 1969 National Security Memorandum 35 (excerpts)
- The U.S. shall renounce the use of lethal biological agents and weapons and all other methods of biological warfare
- The U.S. will confine its biological research to DEFENSIVE MEASURES, such as immunization and safety measures

20 February 1970 National Security Memorandum 44 (excerpts)
- The U.S. renounces the use of toxins as a method of warfare
- The U.S. will confine its military programs for toxins, whether produced by bacteriological or any other biological method or by chemical synthesis, to research for DEFENSIVE purposes only, such as to improve techniques of immunization and medical therapy

10 April 1972
- "Convention of the prohibition of the development, production and stockpiling of bacteriological (biological) and toxin weapons and on their destruction," signed at Washington, London, and Moscow this date
- BW capability destroyed - Medical Biological Defense Research Program continues

Figure VI-9. International Policies on Biological Warfare

	OFFENSIVE		DEFENSIVE
1941-43	Threat identified		
1943	Fort Detrick established		
1950	Program expanded Pine Bluff established		
		1956	TSG initiates medical defensive studies following MOU with CG, Chemical Corps
1969	Offensive use unilaterally renounced and offensive program disbanded	1969	Research initiated in new facility, U.S. Army Medical Research Institute of Infectious Diseases
1970-72	All offensive weapons and seed stocks destroyed		
1972	"Convention of the prohibition of the development, production and stockpiling of bacteriological (biological) and toxin weapons and on their destruction" signed on April 10	1972	Medical Defense Program expanded
		1976	DoD Direction 5160.05 - Army assigned as the executive agent for all biological defense research and development
		1984	Medical defense program realigned to address new biothreats and increase emphasis on previously identified but minimally explored toxins • Ion channel blockers • Presynaptic neurotoxins
		1985	Biodefense functional area analysis for the vice chief of the Army; resulted in 160 additional civilian authorizations and no additional funds
		1988	DCSOPS concept paper, a strong defensive program is recognized as a deterrent
		1989	Neuroscience assets devoted to the effort on defense against chemical nerve agents transferred to the medical defense program to address neurotoxins; dollars, people, and facilities transferred

Figure VI-10. Medical Biological Defense Program History

Threats, Countermeasures, and Technical Barriers. Countermeasures and technical barriers to their implementation that are associated with the threats addressed by the Biological Defense Research Program area are identified below.

Threat Category: Viruses

Countermeasures:
- Drugs with nonspecific antiviral activity
- Vaccines conveying immunity against multiple agents
- Antibodies
- Devices to detect and identify viral threats

Technical Barriers:
- Appropriate model systems for investigation of viral countermeasures
- Required pharmacological characteristics of prophylactic drugs
- Production of polyvalent vaccines against virus classes
- Expression vectors for recombinant products (vaccines and antibodies)
- Nontoxic antiviral drugs
- Immune system enhancement
- Broad-spectrum countermeasures to genetically engineered threats
- Rapid virus identification technology

Threat Category: Neurotoxins

Countermeasures:
- Drugs to counteract common neurotoxin effects
- Antibodies (antitoxins) directed against common features of neurotoxin molecules
- Vaccines
- Reagents to rapidly identify neurotoxins either specifically or as members of the neurotoxin class

Technical Barriers:
- Appropriate model systems for the investigation of neurotoxin countermeasures
- Required pharmacological characteristics of pretreatments and antidotes
- CNS-active drugs without CNS side effects
- Generation of immune responses to small molecules
- Production of polyvalent vaccines against toxin classes
- Expression vectors for recombinant products (vaccines and antitoxins)
- Broad-spectrum countermeasures to genetically engineered threats

Threat Category: Hepatotoxins

Countermeasures:
- Drugs to counteract common hepatotoxin effects
- Antibodies (antitoxins) directed against common features of hepatotoxin molecules
- Vaccines
- Reagents to rapidly identify hepatotoxins either specifically or as members of the hepatotoxin class

Technical Barriers:
- Appropriate model systems for the investigation of hepatotoxin countermeasures
- Required pharmacological characteristics of pretreatments and antidotes
- Generation of immune responses to small molecules
- Production of polyvalent vaccines against toxin classes
- Expression vectors for recombinant products (vaccines and antitoxins)
- Broad-spectrum countermeasures to genetically engineered threats

Threat Category: Protein-inhibiting Toxins

Countermeasures:
- Drugs to counteract common effects of protein-inhibiting toxins
- Antibodies (antitoxins) directed against common features of protein-inhibiting toxin molecules
- Vaccines
- Reagents to rapidly identify protein-inhibiting toxins either specifically or as members of their class

Technical Barriers:
- Appropriate model systems for the investigation of countermeasures to protein-inhibiting toxins
- Required pharmacological characteristics of pretreatments and antidotes
- Generation of immune responses to small molecules
- Production of polyvalent vaccines against toxin classes
- Expression vectors for recombinant products (vaccines and antitoxins)
- Broad-spectrum countermeasures to genetically engineered threats

Threat Category: Membrane-active Toxins

Countermeasures:
- Drugs to counteract common effects of membrane-active toxins
- Antibodies (antitoxins) directed against common features of membrane-active toxin molecules
- Vaccines
- Reagents to rapidly identify membrane-active toxins either specifically or as members of their class

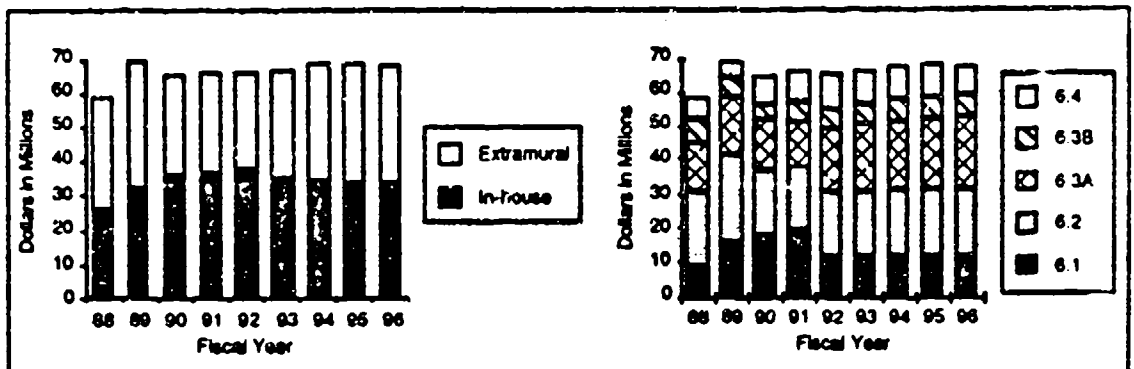
Technical Barriers:
- Appropriate model systems for the investigation of countermeasures to membrane-active toxins
- Required pharmacological characteristics of pretreatments and antidotes
- CNS-active drugs without CNS side effects
- Generation of immune responses to small molecules
- Production of polyvalent vaccines against toxin classes
- Expression vectors for recombinant products (vaccines and antitoxins)
- Broad-spectrum countermeasures to genetically engineered threats

Threat Category: Physiologically Active Compounds (Endogenous Bioregulators)

Countermeasures:
- Antidotes to the effects of PACs
- Antibodies to PACs to use as post-exposure scavengers
- Reagents to rapidly identify PACs

Technical Barriers:
- Appropriate model systems to investigate PAC countermeasures
- Required pharmacological characteristics of antidotes
- CNS-active drugs without CNS side effects
- Generation of immune responses to small molecules
- Expression vectors for recombinant products (antibodies)

Projected Budgets. Projected budgets for the Medical Biological Defense Research Program area through FY96 are identified in Figure VI-11. Funding is projected by FY for extramural versus in-house research, technology base categories, and program elements and projects.



FISCAL YEAR ($K)*

PE	PROJ	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96
61102	BS12	8672	15524	17857	19630	12208	12311	12100	12221	12343
62787	3BL + A871	21610	25851	19522	18306	18695	18955	19287	19480	19675
63002	D807	14429	17118	14438	13572	18531	19185	19964	20164	20365
63807	D809	7500	5061	4932	5459	6008	6109	6251	6314	6377
64807	D847	6134	5622	7679	9342	10422	9844	9994	10076	8833
	TOTAL	58345	69176	64428	66309	65864	66404	67596	68255	67593

* Effective circa 25 August 1989; subject to variation FY 90-96

Figure VI-11. Projected Budgets through FY96 for the Medical Biological Defense Research Program

Military AIDS Research

Mission, Goals, and Objectives. The Military AIDS Research Program focuses on the epidemiology and natural history of HIV infections in military and military-associated populations, on improving methods for rapid diagnosis and patient evaluation, and on studies of the immune response to HIV infection, including the potential for increased risk in the military operational environment [Secretary of Defense Memo for Secretaries of Military Departments, Joint Chiefs of Staff, et al., Caspar Weinberger, 20 April 1987]. The U.S. Army Medical Research and Development Command has been designated the lead agency for the research program; it budgets for and funds all DoD HIV research efforts in accordance with guidance provided by the Assistant Secretary of Defense for Health Affairs [ASD(HA)]. Within the USAMRDC, the Military AIDS Research Program has been placed in the Infectious Disease Research Program area as a special subcategory.

The goals of the AIDS program include preventing disease in Armed Forces personnel and minimizing the cost of HIV infections to the DoD. These goals are addressed by five Congressionally defined research areas: diagnosis, natural history, epidemiology, vaccine development, and chemotherapy. Figure VI-12 provides a synopsis of the considerations associated with the threat of AIDS to the military.

The challenges of the AIDS research effort include: preventing exposure/transmission of HIV, controlling infection, protecting the blood supply, protecting personnel, establishing and maintaining a data base, rapid diagnosis, surveillance of the disease, studying the immune response, performing patient evaluation, performing epidemiological studies, and studying the natural history of the Human

Immunodeficiency Virus (Figure VI-13). In the current research, maximum use is made of the unique characteristics of military populations, such as the broad cross-sectional nature of the community, their potential to be deployed to almost any area of the world, and their susceptibility to the disease.

General Considerations	Warfighting Considerations	Peacetime Considerations
Worldwide distribution	Field blood transfusions and supply	Shore leave in endemic areas
Destabilization of governments	Navy "walking" blood bank policy	Health care costs
Host country entrance requirements	Medical support to Special Operations Forces (SOF)	
Host country resource constraints: – Medical facilities – Blood – Personnel	Health threat to force	
	Unit morale and cohesion	
	National concern	

Figure VI-12. Military Considerations with Respect to AIDS

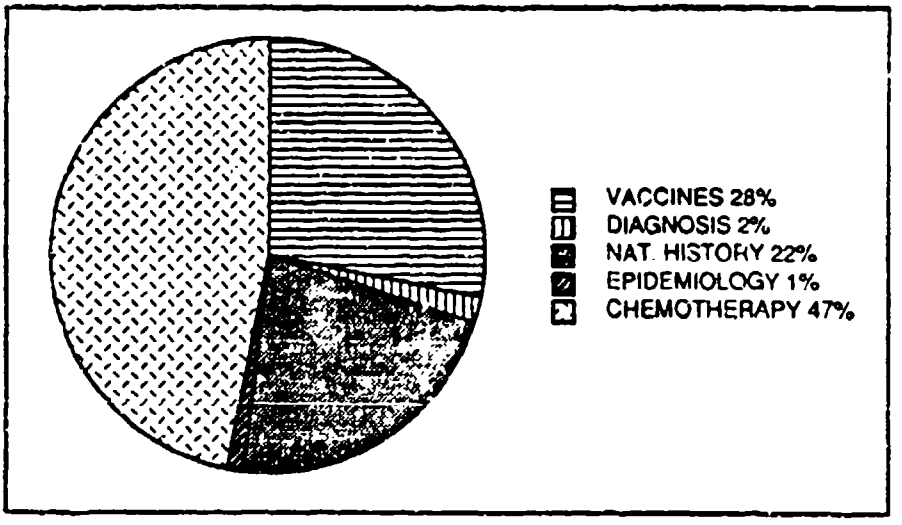


Figure VI-13. AIDS Investment Strategy (FY90)

Threats, Countermeasures, and Technical Barriers. Proposed countermeasures to the military AIDS threat are screening tests, vaccines, drugs, and behavioral change. Technical barriers to AIDS drugs and vaccines are similar to those for other virus countermeasures, and include the following:

- Appropriate model systems for investigation of AIDS countermeasures
- Required pharmacological characteristics of prophylactic drugs
- "Polyvalent" vaccines effective against the ever-proliferating number of AIDS strains
- Expression vectors for recombinant products (vaccines)
- Nontoxic antiviral drugs
- Prevention of drug resistance development
- Immune system enhancement

Very rapid screening technology for AIDS infection is also essential for the Army to protect its "walking blood bank." Research into effective mechanisms for behavior modification is the purview of the USAMRDC.

Non-DoD and DoD Tri-Service Participation. The Tri-Service participants and their areas of research are: the Army [recombinant enzyme-linked immuno-absorbent assay (ELISA), WRAIR clinical staging system, country prevalence rates, genetic diversity of HIV strains, Suramin and azidothymidine (AZT) trials], the Navy (epidemiological studies in the Philippines, Egypt, Peru, and Okinawa); the Uniformed Services University of Health Sciences (USUHS) (clinical studies); and the Henry M. Jackson Foundation for the Advancement of Military Medicine (clinical research unit). Program coordination exists through formal agreements: the Health Services Command (HSC) and the USAMRDC through a MOU; the USAMRDC cooperative agreement in coordination with the Jackson Foundation (NIH, USUHS, and HSC participation); the NIH and the USAMRDC contract management information exchange agreement; the DoD nomination of individuals to Public Health Service committees; and, the DoD and the FDA through a MOU.

MEDICAL CHEMICAL DEFENSE

Mission, Goals, and Objectives

The mission of the Medical Chemical Defense Research Program area is to preserve combat effectiveness by timely provision of medical countermeasures in response to Joint Service CW defense requirements [DoD Directive 5160.5, 30 March 1976].

The Medical Chemical Defense Research Program has three broad goals: 1) to maintain a technological capability to meet present requirements and counter future threats (technology base capability); 2) to provide individual-level prevention and protection to preserve fighting strength (soldier protection); and 3) to provide medical management of chemical casualties to enhance survival and expedite and maximize return-to-duty. Below is an abbreviated list of products, preproducts, or doctrinal or training influences that have been developed in the Medical Chemical Defense Research Program to address the three respective goals.

Goal 1: Maintain technological capability to develop timely countermeasures for classical and emerging threats
- Identify biomedical effects of chemical warfare agents (CWA)
- Determine chemical agent exposure limits
- Develop and validate model systems
- Develop analytical methods for quantifying chemical agents in tissue samples

Goal 2: Provide individual-level protection from CWAs
- Mark I nerve agent antidote kit
- Pyridostigmine (nerve agent pretreatment)
- XM291 skin decontaminating kit
- Convulsant antidote for nerve agent

Goal 3: Provide medical management of chemical casualties to enhance survival, and expedite and maximize return-to-duty
- Cyanide antidote
- Patient wrap, CWA protective
- Litter, folding, decontaminable
- Convulsant antidote for nerve agent
- Provide research support for:
  - FM 8-285, Treatment of Chemical Agent Casualties and Conventional Military Chemical Injuries
  - NATO Handbook on Medical Aspects of NBC Defensive Operation (AMedP-6)

The objectives of the program differ with the varying threats:

- Nerve agents - Field a safe and effective anticonvulsant nerve agent antidote, and develop and field a safe and effective nerve agent pretreatment
- Blister agents - Develop and field a safe and effective topical protectant against CW agents, and develop a pathophysiology data base on vesicant CWA to be used with associated technologies to formulate definitive care and treatment strategies (ultimately to develop a safe and effective pretreatment for blistering CWA)
- Emerging threat agents - Develop approaches to pretreatment and treatment
- Blood agent (i.e., cyanide) - Develop and field an effective cyanide pretreatment

The current Medical Chemical Defense Research Program emphasizes reduction of incapacitation as a design criterion for medical countermeasures. The means by which the USAMRDC is addressing these problems are as follows:

- Biochemical studies to determine mechanisms and sites of action, and effective medical countermeasures for vesicants
- Basic pharmacokinetic studies on CW agent skin penetration rates
- Effective and nondebilitating pretreatments and prophylaxes for cyanide
- Synthesis and efficacy testing of novel anti-CW agent pharmaceuticals
- Characterization of pathophysiological effects of vesicants
- Development of *in vitro* and *in vivo* testing models
- Discovery, design, synthesis, and efficacy assessment of pharmaceuticals effective in reducing the incapacitating central nervous system actions of nerve agents
- Antibody technology and molecular biochemistry as applied to the development of more effective CW agent prophylaxes and pretreatments
- Development of basic analytical methodologies to support research on medical countermeasures to CW agents
- Fundamental and applied research on safe decontaminating and detoxifying compounds
- Molecular modeling of receptors and/or associated enzymes based on crystallographic data, sequence data, or site characterization
- Characterization of the type, sequence, extent, and duration of signs and symptoms as a function of exposure routes and dose of CW agents
- Modification or development of *in vitro* models for application in performing screening and/or toxicology studies on compounds

Accomplishments of this mission area are shown in Section II.

The Medical Chemical Defense Research Program has entered into several joint Service, Service-specific, and international agreements to counter possible emerging threats (Figure VI-14) (see Section III for details). These agreements enable technical data exchange at the scientific level, early identification of the potential for standardization, and complementary rather than redundant research. The Joint Service Agreements specify 45 requirements (see Appendix D).

- Joint Service Agreement (JSA)
  - 45 JSA Requirements
- Service Specific Requirements
- Cooperative International Agreements
  - Mutual Weapons Development Data Exchange Agreements (medical annexes)
  - NATO, Panel VIII, Research Study Group 3
  - The Technical Cooperation Program, Subgroup E
  - U.S.-U.K.-Canada Memorandum of Understanding

Figure VI-14. Sample of Agreements

Primary DoD Participating Laboratories

The primary DoD laboratories participating in the Medical Chemical Defense Research Program and their areas of research are: U.S. Army Medical Research Institute of Chemical Defense, Principal Laboratory (drug screening and evaluation, study of basic mechanisms of action of CWA compounds, pathophysiology and pharmacology of CWA compounds, defining technology base deficiencies in terms of data gaps); Walter Reed Army Institute of Research (drug discovery, degradation studies of antidotes and pretreatments); U.S. Army Aeromedical Research Laboratory (aviation-based performance studies of antidotes and pretreatments, effects of antidotes and pretreatments on visual systems); and U.S. Army Research Institute for Environmental Medicine (defining combined effects of candidate pharmaceuticals, countermeasures, and environmental stresses -- including MOPP levels -- on performance).

Threats, Countermeasures, and Technical Barriers

The classical threat categories include: vesicants or blister agents (e.g., mustards and lewisite), blood agents (e.g., cyanide), choking agents (e.g., phosgene), and nerve agents (e.g., GA, GB, GD, and VX -- these threats may include other chemical neurotoxins). The threats, however, are not restricted to commonly accepted classical agents. Novel agents may be developed by potential adversaries. The ability to provide timely and effective medical countermeasures to new threats depends upon maintaining the capability to develop such countermeasures. Therefore, the scope of the Medical Chemical Defense Research Program encompasses both potential and classical threats.

The countermeasures include pharmaceuticals, medical equipment, specialized materiel or medical procedures and concepts for doctrine, organization, and training. Medical countermeasures are designed to preserve and sustain combat effectiveness in the face of combined threats from chemical and conventional munitions on the integrated battlefield, by:

- Prevention of the effects of CW agent (e.g., pretreatment or prophylaxis),
- Far-forward treatment upon exposure to chemical warfare threats (e.g. antidotes), and
- Chemical casualty care (e.g., therapy and management).

Threat Category: Nerve Agents

Countermeasures:
- Anticonvulsant antidote to prevent or minimize convulsions and brain injury
- Pretreatment regimen that protects against incapacitating effects

Technical Barriers:
- Appropriate model systems for identifying promising chemical structures
- Required pharmacological characteristics of pretreatments/antidotes
- CNS-active drugs without CNS side effects

- Generation of immune responses to small molecules (for production of scavenging antibodies)
- Expression vectors for recombinant products (scavengers)

Threat Category: Blister Agents

Countermeasures:
- Topical protectants to protect skin against blister (and thickened nerve) agents
- Biological/pharmaceutical product to prevent cell death caused by vesicant agents

Technical Barriers:
- Trade-off between reactive or catalytic decontaminant activity and safety of protectant compounds
- Appropriate model systems for the identification of countermeasure approaches
- Required pharmacological characteristics of pretreatments/antidotes

Threat Category: Blood Agent (Cyanide)

Countermeasures:
- Pretreatment is the most reasonable approach because of the rapid action of cyanide

Technical Barriers:
- Appropriate model systems for efficient identification of active compounds and evaluation of pretreatment approaches
- Required pharmacological characteristics of pretreatments

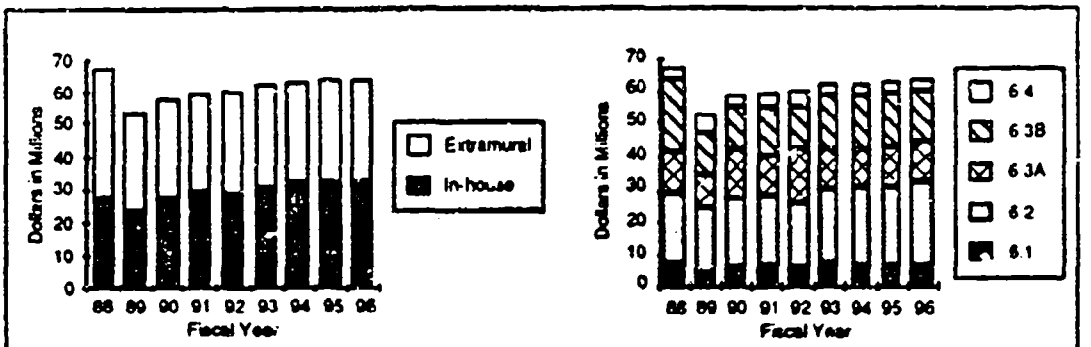
Threat Category: Emerging Threat Agents (e.g., Pulmonary)

Countermeasures:
- Short-term: Health risk criteria for emerging threat doctrine, care and treatment strategies
- Intermediate-term: Specific casualty management techniques to improve survival and return-to-duty
- Long-term: Pharmaceutical/biological pretreatments, antidotes, or decontaminants/protectants

Technical Barriers:
- Appropriate model systems for the study of agent effects and investigation of countermeasure approaches
- Fast and easy casualty stabilization methods
- Required pharmacological characteristics of pretreatments/antidotes
- Trade-off between reactive/catalytic decontaminant activity and safety of decontaminants and protectants
- Generation of immune responses to small molecules
- Expression vectors for recombinant products
- CNS-active drugs without CNS side effects

Projected Budgets

Projected budgets for the Medical Chemical Defense Research Program area through FY96 are identified in Figure VI-15. Funding is projected by FY for extramural versus in-house research, technology base categories, and program elements and projects.



FISCAL YEAR ($K)*

PE	PROJ	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96
61102	BS11	7062	4434	5951	6392	6722	6672	6454	6519	6584
62787	875	21677	19777	21227	20047	21976	23855	24528	24773	25021
63002	995	12099	9668	14398	15794	11355	11803	12038	12158	12280
63807	993	22178	13271	13150	12746	15732	15861	16024	16184	16346
64807	848	3871	5660	3286	3054	3572	3615	3680	3717	3754
TOTAL		66885	52810	58012	58033	59357	61806	62724	63351	63985

* Effective circa 25 August 1989, subject to variation FY 90-96

Figure VI-15. Projected Budgets through FY96 for the Medical Chemical Defense Research Program

COMBAT CASUALTY CARE

Mission, Goals, and Objectives

The mission of the Combat Casualty Care Research Program area is to conduct research to expedite the return-to-duty of soldiers sustaining non-life-threatening wounds, injuries, and dental-maxillofacial emergencies; direct research towards reducing the morbidity and mortality associated with major battlefield wounds and injuries including maxillofacial injuries; and, direct research and development programs at miniaturizing, automating, field-hardening, and increasing the portability of medical and dental diagnostic and therapeutic equipment. [DoD Appropriations Bill, 1982 (Report of the Committee on Appropriations, Report #97-333, page 247); Army Requisition 70-1, "Research, Development, and Acquisition - Systems Acquisition Policy and Procedures," Chapters 2-34, 10 October 1988; and USAMRDC Memorandum 10-1, "Organization and Function," 8 August 1985, direct that the Army be designate[illegible] lead agency for combat dentistry research and development.]

The program has four components. The first is to improve the medical, surgical, and dental treatment and management of battlefield trauma. The Combat Casualty Care Research Program is the only USAMRDC program that is primarily concerned with treatment of the battlefield casualty rather than the prevention of casualties. Second, emphasis is placed on research and development that improves the treatment of trauma that requires major resuscitation or worsens if management is delayed, hastens the return-to-duty of the soldier, and is militarily-unique. Much of this research program has no civilian counterpart. The third component is to develop medical equipment that is as nearly state-of-the-art as possible. Physicians, dentists, and nurses who staff battlefield hospitals draw on their peacetime medical

education and experience. They must have the tools to apply this experience in the field. Reducing the logistics tail by decreasing the resupply requirements of field hospitals is the fourth area of research emphasis. Field hospitals can be made increasingly self-sufficient by the development of devices that allow them to produce their own intravenous solutions and oxygen, and alternative technologies to eliminate the need for consumable X-ray film and film developer solutions.

The current Combat Casualty Care Research Program has two major goals that relate to the severity of injury: 1) enhancing the rapid return-to-duty in the forward battle area of soldiers who have sustained non-life-threatening wounds or injuries, and 2) reducing the morbidity and mortality from battlefield episodes of major physical or psychological trauma.

The objectives of the program are:

- Early resuscitation and treatment - Improving treatment of shock, improving blood storage and processing, developing blood substitutes, preventing organ system failure
- Wound healing - Improving treatment of burns, accelerating new tissue regrowth in wounds, preventing wound infection
- Materiel support of field medical units - Developing devices to improve the diagnostic and therapeutic capability of field hospitals and throughout the evacuation system, reducing the need for medical resupply, improving storage and handling of medical supplies
- Surgical research - Establishing a military trauma research community with sufficient clinical credibility to eventually assume national and international leadership in the range of trauma management technical initiatives, innovations, and activities

Combat casualty care areas currently under investigation are listed below.

- Shock and resuscitation - Limit or decrease morbidity and mortality due to unavoidable delays between hemorrhage and volume or blood replacement
- Wound management and the enhancement of healing - Development of new techniques and evaluation of pharmacologic modification of wound healing
- Thermal burns - Development of improved techniques for management of burn injuries that are major contributors to battlefield morbidity and mortality
- Sepsis - Development and evaluation of new methods to prevent, diagnose, and treat infections resulting from battlefield injuries
- End-organ failure - Conduct studies directed at preventing organ failure, especially pulmonary and renal, in the severely traumatized patient
- Blood and blood products - Research extending the storage of red blood cells, platelets, and other blood products at freezing, refrigerated, and ambient temperatures; ongoing effort to develop blood substitute materials that are oxygen-carrying resuscitation fluids

A current need of the Combat Casualty Care Research Program is to acquire the intellectual "critical mass" for a high quality program in the trauma clinical care community. This may be achieved by establishing a single Center of Excellence for trauma management research. The Center would consider problems in both burn and mechanical trauma and include research to improve materials and techniques for the medical, surgical, and psychiatric management of victims. This Center would provide a focus for plans to integrate basic, advanced, and applied research with hands-on training and continuing education for trauma care providers. With this approach, decision-makers will have a better scientific basis for the timely evaluation of field medical care doctrine.

A separate field effort includes examining the use of medical and dental equipment and material in far-forward, forward, and intermediate battlefield locations. Emphasis is on equipment that is inherently reliable, simple, sturdy, lightweight, easily repairable, and easily transportable without excessive assembly or disassembly.

A special area of emphasis in the Combat Casualty Care Research Program is Combat Dentistry. The combat dentistry research effort focuses on the development of simplified procedures for the care of combat-associated maxillofacial wounds and injuries; minimal morbidity from oral emergencies; preventable oral disease and prevention of dental material failures; and more efficient, simplified, and effective means of protecting the oral health of military personnel.

Mission-specific accomplishments are included in Section II.

Primary DoD Participating Laboratories

The primary DoD laboratories participating in the Combat Casualty Care Research Program and their areas of research are: the U.S. Army Biomedical Research and Development Laboratory, Field Medical Materiel Division (wheeled litter carrier, field medical refrigerator); the U.S. Army Institute of Dental Research (antimicrobial dermal dressing, microencapsulating of antibiotics to treat bone infection); the U.S. Army Institute of Surgical Research (improving early diagnosis of burn wound infection, improving surgical excision techniques for burn treatment); the Letterman Army Institute of Research (stroma-free hemoglobin, improving surgical treatment for gunshot wounds); and the Walter Reed Army Institute of Research (elucidating the mechanism of acute renal failure, improving diagnosis of severe blast injury).

Threats, Countermeasures, and Technical Barriers

Countermeasures and technical barriers to their implementation for the medical threats addressed by the Combat Casualty Care Research Program area are identified below; the last category describes countermeasures applicable to diagnosis and treatment of all physical injuries.

Threat Category: Hemorrhagic Shock

Countermeasures:
- Field-transportable fluid replacement to maintain blood pressure
- Improved blood banking: longer shelf life, faster processing, platelets and clotting factors
- Oxygen-carrying blood substitute
- Treatments to prevent organ system injury or failure

Technical Barriers:
- Appropriate model systems for hemorrhagic shock
- Fast and easy casualty stabilization methods
- Artificial replacement for blood

Threat Category: Burns

Countermeasures:
- Technology to assess severity of burns
- Treatment protocols for burn casualties
- Biological and synthetic skin coverings
- Improved management of infections
- Methods or drugs to accelerate healing

Technical Barriers:
- Weight, size, and power requirements of diagnostic/imaging systems
- Appropriate model systems for burn management
- Artificial replacements for skin
- Rapid bacteria and virus identification
- Prevention of drug (antimicrobial) resistance development
- Immune system enhancement

Threat Category: Mechanical Trauma (Penetrating Injury, Blunt Trauma, Blast Injury)

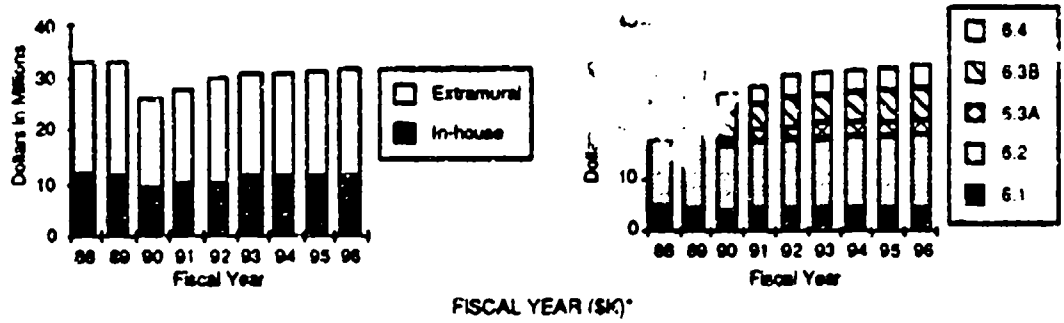
Countermeasures:
- Field x-ray/imaging equipment for far-forward diagnosis and triage
- Biodegradable bone substitute
- Improved management of infections
- Methods or drugs to accelerate healing

Technical Barriers:
- Weight, size, and power requirements of imaging systems
- Appropriate model systems for investigations of wound healing
- Artificial replacement for bone
- Regeneration of neural tissue
- Rapid bacteria and virus identification
- Prevention of drug (antimicrobial) resistance development

Threat Category: Psychological Trauma

Countermeasures:
- Improved treatment of psychiatric casualties

Technical Barriers:
- Appropriate model systems for battlefield stress, stress casualties, and evaluation of treatment regimens
- Neuroscience of psychological stress



FISCAL YEAR ($K)*

PE	PROJ	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96
61102	S14	3881	2797	2690	2782	2886	2934	2994	3024	3054
61102	S16	881	1192	850	1006	1019	1045	1063	1074	1084
62787	825	1130	2350	2409	2507	2599	2754	2919	2948	2978
62787	874	7122	8899	10291**	10515	10778	10982	11121	11232	11345
62787	JDL, 3EL, 3FL	4403	4458	0	0	0	0	0	0	0
63002	840	1282	1528	1644	2424	2586	2641	2684	2711	2738
63807	836	11282	8288	4670	5120	5592	5629	5764	5822	5880
64807	832	2815	3234	3752	3698	4516	4594	4666	4713	4760
	TOTAL	32796	32744	26306	28052	29976	30579	31211	31524	31839

* Effective circa 25 August 1989, subject to variation FY 90-96
** Increase is due to transfer of Administration and Management lines

Figure VI-16. Projected Budgets through FY96 for the Combat Casualty Care Research Program

The following countermeasures are broadly applicable to diagnosis or treatment of all the threat categories of physical injuries.

Countermeasures:
- Devices for early diagnosis and monitoring of injuries: core temperature measurement, blood oxygenation, necrotic tissue detection, etc.
- Devices to manufacture medical-grade oxygen and intravenous fluids on site
- Field refrigeration and sterilization units

Technical Barriers:
- Weight, size, and power requirements of medical equipment

Projected Budgets

Projected budgets for the Combat Casualty Care Research Program area through FY96 are identified in Figure VI-16. Funding is projected by FY for extramural versus in-house research, technology base categories, and program elements and projects.

SYSTEMS HAZARDS

Mission, Goals, and Objectives

The mission of the Systems Hazards Research Program is to establish the knowledge base required to provide protection for soldiers from hazards generated by Army systems and combat operations; enhance soldier effectiveness, performance, and capabilities; and design effective interfaces between the soldier and Army systems.

The current program spans five broad research areas: 1) physiology and performance, 2) psychological factors and soldier performance, 3) toxic hazards, 4) biomechanical stress, and 5) directed energy. The goal of the research conducted in each of these thrust areas is to foster and maintain operational readiness and combat effectiveness by preserving and enhancing physical and mental fitness of the soldier.

The objective of the physiology and performance thrust area is to develop a knowledge base to support doctrinal, training, manpower, or materiel fixes to warfighting deficiencies identified for operations conducted in extremes of heat, cold, or high terrestrial elevations. Research is also conducted to identify methods of preserving or enhancing the physical fitness and ergonomic performance of the soldier, enhancing performance of military tasks through an understanding of sensory physiology, and maintaining or enhancing fighting capabilities through exploitation of recent advances in our understanding of nutrition. The impact of this research is to expand the operational envelope of the soldier in terms of harsh environments or demanding operational scenarios.

The objective of the psychological factors and soldier performance thrust area is to develop a knowledge base to support doctrinal, training, manpower, or materiel fixes to warfighting deficiencies related to combat stress, whether it stems from the unprecedented speed, continuity and lethality of high-intensity airland battle or the uncertainties, ambiguities, and frustrations of low intensity conflict. Research is conducted on the: neurochemical, hormonal and immune response to stresses; physiological factors involved in alertness and sleep as well as effects of sleep deprivation or fragmented sleep; organization of combat units to maximize the protective effects of unit cohesion; leadership and training methods to lessen the impact of massive trauma on surviving unit members; and identification and amelioration of non-combat stresses associated with military life. The impact of this research program is on the maintenance or enhancement of the ability of soldiers and their leaders both to survive and fight the high-intensity war and also to maintain morale and effectiveness in low-intensity conflict.

The objective of the toxic hazards thrust area is to develop a data base to support doctrinal or materiel solutions to problems identified in Army materiel systems as early as possible in the system life-cycle. Research encompasses problem definition, toxicology, epidemiology, field characterization, industrial hygiene, and risk assessment. The impact of this research is found in the publication of design standards and health hazard assessments that are critical elements in the systems acquisition process. These data directly support the timely fielding of combat systems that do not subject the soldier/operator to undue risk of injury.

The objective of the biomechanical stress thrust area is to develop sufficient data on the injuries or performance decrements associated with exposures of soldiers to mechanical stress so that doctrinal, training, or manpower solutions to these problems may be developed. Research programs address the pathophysiology of exposure to continuous or impulse noise, the hearing protection and communication functions of combat-vehicle crewmen helmets, the acute and chronic effects of ground vehicle or aircraft-generated vibration, the biodynamics of impact, and the risk of injury to air-containing organs from exposure to blast overpressure. The data from each of these programs contribute to the creation of military-unique standards that will guide engineers and managers in the development of materiel systems.

The objective of the directed-energy thrust area is to generate data to support the creation of doctrinal, training, or materiel fixes to the health and performance problems encountered by soldiers exposed to a variety of DE sources. Basic and applied research programs are executed on the bioeffects of RF-broadband and laser energy exposures. Additionally, research is conducted on emerging technologies that might have applications in the area of DE protective devices. The impact of this research effort will be the conservation of soldier health and performance in the high technology environment expected on future battlefields.

Accomplishments of the mission are included in Section II.

Primary DoD Participating Laboratories

The primary DoD laboratories participating in the Systems Hazards Research Program and their areas of research are: the U.S. Army Research Institute of Environmental Medicine (performance, nutrition, physical fitness, and environmental extremes); the Walter Reed Army Institute of Research (psychological stress, RF-broadband directed energy); the U.S. Army Biomedical Research and Development Laboratory (toxic hazards); U.S. Army Aeromedical Research Laboratory (biomechanical, psychological, and microenvironmental stress); and the Letterman Army Institute of Research (laser-directed energy). Additional organizational interactions are shown in Figure VI-17.

- DCSPER
- DCSLOG
- Corps of Engineers
- DARPA
- Army Environmental Hygiene Agency
- Naval Air Development Center
- Army Research Institute for the Behavioral and Social Sciences
- Natick Research, Development, and Engineering Center
- Aviation Systems Command
- Army Materiel Command (AMC) Project Managers
- Center for Night Vision and Electro-Optics (CNVEO)

Figure VI-17. Additional Systems Hazards Organizational Interactions

Threats, Countermeasures, and Technical Barriers

Countermeasures and technical barriers to their implementation that are associated with the Systems Hazards Research Program are identified below. Countermeasures include input to doctrine, health standards, and materiel fixes/development plans.

Threat Category: Environmental Hazards

Countermeasures:
- Non-materiel solutions optimizing training and doctrine for environmental extremes
- Materiel solutions - pharmacologic prophylaxis and/or treatment
- Materiel solutions - environmental health monitoring equipment

Technical Barriers:
- Appropriate model systems for investigation of climate and altitude effects and countermeasures
- Required pharmacological characteristics of pretreatments
- CNS-active drugs without CNS side effects
- Weight, size, and power requirements for health monitoring equipment

Threat Category: Psychological Stress

Countermeasures:
- Non-materiel solutions to minimize performance decrements due to battlefield stress
- Non-materiel solutions to optimize unit and individual performance under stress
- Materiel Solutions - pharmacologic prophylaxis and/or treatment

Technical Barriers:
- Appropriate model systems for investigation of sleep deprivation, attention and alertness, and military stress
  - Effects on performance
  - Evaluation of preventive measures
- Neuroscience of psychological stress

Threat Category: Toxic Hazards

Countermeasures:
- Non-materiel solutions to assess and reduce battlefield toxic hazards
- Materiel and non-materiel solutions to counter battlefield toxic hazards
- Non-materiel solutions to evaluate environmental hazards that result from military training exercises and military industrial operations

Technical Barriers:
- Appropriate model systems for identifying toxic hazards and setting exposure limits

Threat Category: Biomechanical Stress

Countermeasures
- Materiel and non-materiel solutions to minimize blast overpressure hazards
- Materiel and non-materiel solutions to minimize vibration and mechanical stress hazards
- Physical fitness, nutrition, military training and work guidelines

Technical Barriers:
- Appropriate model systems for investigating protection from auditory and non-auditory effects of blast overpressure, and setting limits for whole-body vibration exposure
- Optimization of fitness training and nutrition to maximize effectiveness of military performance and reduce injuries

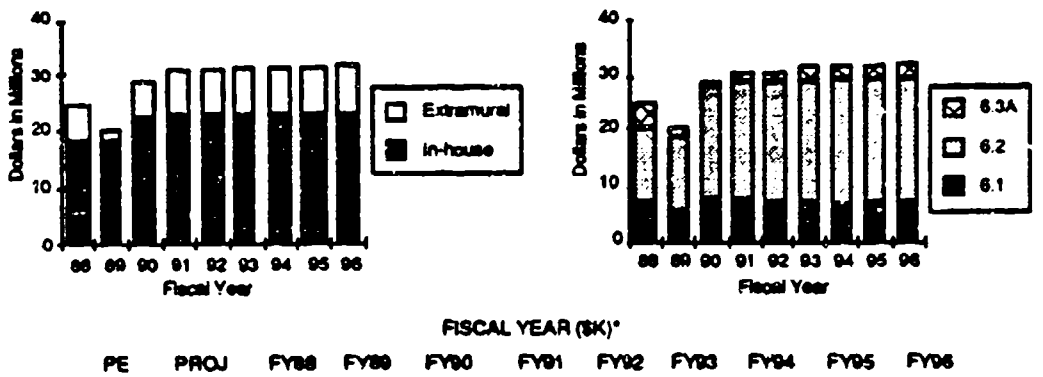
Threat Category: Directed Energy

Countermeasures
- Materiel and non materiel solutions to defeat the effects of DE weapons on the soldier

Technical Barriers:
- Appropriate model systems for investigating mechanisms and prevention of directed energy injury
- Approaches to protection against specific directed energy threats

Projected Budgets

Projected budgets for the Systems Hazards Research Program area through FY96 are identified in Figure VI-18. Funding is projected by FY for extramural versus in-house research, technology base categories, and program elements and projects.



FISCAL YEAR ($K)*

PE	PROJ	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96
61102	BS15	6830	5152	7643	7543	7067	6946	6709	6776	6844
62787	A878	8473	8237	10527**	11145	11261	11462	11646	11782	11880
62787	A879	4723	5423	9745**	9930	10255	10422	10598	10704	10811
63002	D819	4595	1289	819	2126	2178	2377	2418	2442	2467
	TOTAL	24621	20101	28734	30774	30761	31207	31371	31704	32002

* Effective circa 25 August 1989; subject to variation FY 90-96
** Increase is due to transfer of Administration and Management lines

Figure VI-18. Projected Budgets through FY96 for the Systems Hazards Research Program

TECHNICAL BARRIERS

Many potential systems that are attractive to the Army and the Army medical community cannot be demonstrated in the next few years because the technology does not exist. Technology gaps reveal that many future systems have common needs for advanced technology. These technology barriers are a focus for the basic and applied research to be performed by the Army technology base community. They will facilitate the identification of those emerging technologies that will provide the greatest support to future systems. Examples of technological barriers and the research ongoing and proposed to address them are presented below.

Technical Barrier #1: Appropriate Model Systems

Experimental model systems must be developed and validated for their ability to predict drug or treatment efficacy and safety in humans. Additional models are needed to predict the medical and

psychiatric effects of conventional, chemical, and DE weapons systems. Much current research employs model systems requiring a validated basis for extrapolating results to man. Cell culture systems and other *in vitro* techniques are needed to facilitate the screening of large numbers of drugs for a particular application in a short period of time. Development and validation of nonliving model systems are also highly desirable goals to improve research efficiency and cost-effectiveness.

The USAMRDC is responding to this barrier with research that includes:

- Validation of skin culture models for vesicant effects research and screening of vesicant countermeasures,
- Development of cellular model systems for drug screening in accordance with decision network criteria,
- Experimental approaches combining computerized data analysis and extrapolation with animal studies to use fewer than one-tenth the number of animals used in standard factorial experimental designs, and
- Preliminary development of computer models for biological sites of action; for prediction of drug effects from molecular structures; and to replace animals used in live fire, toxic gas, and blast overpressure studies.

Technical Barrier #2: Required Pharmacological Characteristics of Pretreatments/Antidotes

Pretreatments and antidotes against disease, climate and altitude effects, sleep deprivation, and the toxic effects of BW or CW agents must be easy for the soldier to carry and use. Pretreatment drugs should be given orally or transdermally. They should be effective for at least 12-24 hours, or possibly even indefinitely, with immunological approaches. Antidotes should be administered intramuscularly (through MOPP for BW/CW antidotes) and should take effect almost immediately. Because many drugs do not meet these requirements, a search continues for effective countermeasures with different pharmacokinetic characteristics and for novel methods of drug administration.

The USAMRIID, the USAMRICD, the USARIEM, and the WRAIR are conducting research that addresses this barrier, including:

- Pharmacokinetic studies on candidate pretreatment and antidote drugs,
- Basic studies on new technology for drug formulation and administration, and
- Research on immunological approaches to long-lasting prophylaxis against disease and BW or CW agents.

Technical Barrier #3: CNS-active Drugs with Acceptable Side Effects

Many CW agents or toxins have toxic effects on the central nervous system (CNS). In addition, drugs that affect sleep or promote climate or altitude tolerance are active in the CNS. Drugs that counteract these CNS effects often have side effects of their own that affect CNS function. In addition, drugs that affect sleep or promote climate or altitude tolerance are active in the CNS. The aim is to find drugs with minimal detrimental effects on military task performance that are still effective pretreatments or antidotes against the toxic CNS effects of CW agents and toxins, or that enhance deployment capabilities and maintain soldier alertness in various environments.

The USAMRICD, the WRAIR, the USAARL, and the USARIEM are conducting research to address these barriers, including:

- Studies on the behavioral effects of potential CW and toxin countermeasures;
- Studies on pharmacological enhancement of performance by reducing jet lag and fatigue during deployment;

- Development of a task analysis data base to allow identification of military tasks for modeling of military performance from discrete task effects and elaboration of sequential network computer models to quantify risk;
- Studies on the mechanisms by which CW agents, neurotoxins, and countermeasures affect the CNS; and
- Development of more effective prophylaxes, pretreatments, and antidotes, free of performance-related side effects.

Technical Barrier #4: Reactive/Catalytic Decontaminant Activity versus Safety of Decontaminant and Protectant Compounds

Compounds with broad-spectrum reactivity or catalytic activity toward CW agents would be useful decontaminants or components of topical skin protectants. However, the same chemical attributes that make a compound highly reactive generally also make it highly irritating or toxic to human skin; i.e., these substances may penetrate and/or react with skin tissue. New compounds or new approaches are needed to achieve broad-spectrum effectiveness, safety, and lack of irritation.

The USAMRICD is conducting research to develop:

- Decontaminants structured with reactive sites contained inside pores for CW agent entry and unreactive sites on the exterior that contacts skin,
- Catalytic molecules with high turnover numbers to detoxify large amounts of CW agents with small quantities of decontaminants, and
- Bioengineered enzymes of high catalytic specificity that could be combined for broad-spectrum activity.

Technical Barrier #5: Production of Polyvalent Vaccines Effective against Disease or Toxin Classes

Standard vaccine development techniques produce vaccines that are specific for a single strain of disease-producing virus or bacteria. Consequently, a number of vaccines are needed to produce immunity to all the forms of dengue, or the hemorrhagic fevers, or the multiple versions of meningitis. In addition, vaccines under development against toxin threats are unlikely to confer immunity against all toxins with similar molecular mechanisms. As a result, protection of a soldier from all the endemic diseases and biological warfare threats he may encounter could involve a large number of vaccinations. Such an assault on the soldier's immune system is neither desirable nor practical. Ways are needed to confer immunity to several disease and/or biological warfare threats with a single vaccine.

The USAMRIID and the WRAIR are addressing these problems through:

- Examination of various potential viral and bacterial carriers for polyvalent vaccines,
- Development of a candidate multivalent vaccine by insertion of foreign genes into a bacterial carrier,
- Studies to elucidate highly conserved regions of surface antigens to target vaccines to less changeable sites,
- Structural and immunological characterization of toxin molecules to search for common antigenic sites, and
- Development of a heptavalent toxoid for the various serotypes of botulinum toxin.

Technical Barrier #6: Generation of Immune Response to Small Molecules

A number of agents of biological origin, PACs, and CW agents are too small to be antigenic and thus antibodies cannot normally be made to these molecules. In order to use vaccine or antibody approaches to protect soldiers against these threats, ways must be found to generate antibodies that will recognize and bind these molecules.

The USAMRIID, the WRAIR, and the USAMRICD are examining:

- Coupling of small molecule threat agents to large molecules to generate antibodies to the small molecule,
- Production of synthetic analogues of small molecule threat agents that have an antigenic site resembling the agent, and
- Structures of threat agents to determine necessary structure of potential antigens.

Technical Barrier #7: Nontoxic Antiviral Drugs

Viruses consist principally of genetic material (DNA or RNA) surrounded by a protein coat. Their only function is replication. Consequently, viruses offer few targets for the activity of antiviral drugs. Most current antiviral drugs inhibit the synthesis of DNA or RNA. However, DNA and RNA synthesis occurs in most human cells, and these antiviral drugs are highly toxic to human cells undergoing rapid growth and replication. As a result, antiviral drug therapy is usually reserved for life-threatening illnesses. Nontoxic antiviral drugs are needed to protect soldiers from viral biological warfare agents and from viral endemic diseases.

The USAMRIID and the WRAIR are conducting:

- Research on basic mechanisms of virus infection,
- Studies on prevention of virus entry into host cells, and
- Synthesis of potential antiviral drugs that will cross the blood-brain barrier.

Technical Barrier #8: Expression Vectors for Recombinant Products

Through current technology, DNA containing any gene or genes of interest can be manufactured. However, insertion of such a gene into a vector that will express the gene's product in useful quantities is still a significant problem. Recombinant DNA technology offers the most promise for rapid production of new vaccines and toxoids, and for creation of polyvalent vaccines against multiple diseases. Recombinant products are also important tools for examining the mechanisms of actions of threat agents. Viral, bacterial, and eukaryotic expression vectors are needed for these various applications.

The USAMRIID and the WRAIR are:

- Monitoring biotechnology industry progress in expression technology to rapidly exploit new developments,
- Conducting studies of recombinant vaccinia viruses containing genes for potential antigens from disease-causing viruses , and
- Making comparisons of several bacterial vectors as recombinant vaccine carriers.

Technical Barrier #9: Rapid Bacteria and Virus Identification

Techniques are needed to detect and identify: 1) biological warfare threat agents, 2) endemic diseases in deployment areas, and 3) viral and bacterial infections in soldiers. Traditional methods employ time-consuming and logistically burdensome isolation and culture techniques. New technologies are being explored for rapid, easy-to-use, unambiguous identification of infectious agents.

The USAMRIID and the WRAIR are:

- Producing monoclonal antibodies specific for all pathogenic viruses and bacteria under study as threats,
- Investigating immunochemical techniques for virus and bacteria identification,
- Developing nucleic acid probes for specific organisms, and
- Exploring polymerase chain reaction for diagnosis of infectious agents.

Technical Barrier #10: Broad-spectrum Countermeasures to Genetically Engineered Threats

Current countermeasure technology (particularly vaccines, toxoids, and antibodies) for soldier protection and biological warfare threat identification cannot cope with presently unknown organisms and molecules. Less specific, broad-spectrum approaches to pretreatments and antidotes are needed to provide adequate protection from these new threats.

The USAMRIID, the WRAIR, and the USAMRICD are conducting the following research addressing this barrier:

- Exploration of drugs to nonspecifically enhance immune system function,
- Studies on basic mechanisms of immune system activation,
- Synthesis and screening of potential antiviral drugs with broad-spectrum activity,
- Studies on basic mechanisms of infection by viral and bacterial pathogens, and
- Determination of structural similarities between toxins with similar mechanisms of action to make antagonists to key common structures instead of to specific molecules.

Technical Barrier #11: Prevention of Drug-resistance Development

Disease-producing organisms often develop strains resistant to current antibiotic or antiparasitic drugs used to treat those diseases; for example, with extensive use, resistance has been known to occur to antimalarial drugs in as little as 5 years. Consequently, a search must continue for next-generation drugs to prevent or treat these diseases. Ways to prevent the development of drug-resistant pathogens are needed for more effective and less costly control of infectious disease.

The WRAIR is conducting:

- Searches for drugs effective at reversing drug resistance or potentiating drug activity, and
- Basic research on the mechanisms of development of drug resistance.

Technical Barrier #12: Improved Biological Controls for Disease Vectors

With very few exceptions, pesticides effective in the control of disease vectors are potentially hazardous to the environment and must be used carefully. Their use as preventive measures during deployment and for control of endemic diseases in developing countries is therefore limited. Introduction of carefully chosen biological controls could provide less environmentally harmful and longer-lasting control of disease vectors.

The USABRDL is responding to this barrier with programs to:

- Develop a vector control science base to monitor research developments in biological controls,
- Conduct basic research on control of disease vectors of more military interest than commercial interest,
- Test and adapt pesticide sprayer equipment for the dispersion of biological controls, and
- Evaluate Bacillus thuringiensis and Planaria for control of specific disease vectors.

Technical Barrier #13: Weight, Size, and Power Requirements of Medical and Health Monitoring Equipment

Current technology provides an important array of diagnostic and treatment tools. Ways are needed to transport these technologies to the field for use by military medical and combat units. However, many of the technologies (particularly imaging methods) have weight, bulk, and power requirements that make them either difficult (X-ray equipment) or impossible (magnetic resonance imaging and positron emission tomography) to transport with current materials, electronics, and chemical technology.

In response to these problems, the USABRDL is:

- Monitoring research on filmless X-ray and computer tomography equipment that produces a digitized image,
- Examining computerized image storage, processing, and communication technology that will allow image analysis at a remote site,
- Exploring technologies for detection of necrotic tissue by a hand-held unit,
- Examining technologies for portable units to manufacture medical supplies (e.g., intravenous fluids, oxygen) in theater hospitals, and
- Developing field devices for monitoring climatic stress.

Technical Barrier #14: Artificial Replacements for Blood, Bone, and Skin

Replacement tissues from human tissue banks are bulky, must be stored sterile and refrigerated, and must match the tissue type of the recipient. Artificial replacement tissues are needed that are stable, easy to store, nonantigenic, and nontoxic. Ideally, these artificial materials could be stored at ambient temperatures and sterilized immediately before use, would require no tissue typing, and would be biodegradable in situ at a controlled rate compatible with the healing rate of the injury.

The LAIR, the USAIDR, and the USAISR are conducting:

- Studies of oxygen-carrying efficacy and toxicity of acellular hemoglobin solutions;
- Basic research on hemoglobin and platelet function and possible artificial substitutes;
- Research on artificial skin graft materials, burn dressing components, and grafting methods;
- Studies of epidermal growth factors to improve burn healing; and
- Development of biodegradable bone repair material and methods for its fixation.

Technical Barrier #15: Regeneration of Neural Tissue

Fully differentiated nerve cells, such as those found in the human nervous system, are incapable of cell division; therefore, they are presently irreplaceable when lost through injury or disease. As a result, injuries to neural tissue can easily result in permanent physical and/or mental disability. Ways to regenerate damaged neural tissue are needed to enable complete recovery from these injuries.

The WRAIR and the LAIR are addressing these problems through:

- Basic research on effects and biochemical mechanisms of action of nerve growth factors,
- Exploration of electric current stimulation as a means to promote nerve regeneration, and
- Basic research on early development and differentiation of neural tissue to identify and possibly manipulate controlling mechanisms.

Technical Barrier #16: Fast and Easy Casualty Stabilization Methods

Definitive medical treatments cannot be performed on the battlefield. Combat medics and far-forward aid stations need fast, easy-to-perform, logistically simple methods to stabilize casualties for evacuation to prolong the time until definitive treatments are necessary, and thus improve the prognosis for a complete recovery. A particularly critical area for casualty stabilization is the prevention of tissue edema, particularly brain and lung edema.

The LAIR, WRAIR, and USARIEM are addressing this problem through:

- Evaluation of emergency treatments for penetrating head injuries to delay or prevent the need for neurosurgery;
- Identification of drugs to improve acute respiratory distress syndrome;
- Basic research on mechanisms involved in hemorrhagic shock;
- Evaluation of drugs and procedures for the diagnosis, prevention, and treatment of shock; and
- Evaluation of drugs and procedures for protection of the kidneys and prevention of acute renal failure during hemorrhagic shock.
- Basic research on mechanisms of climatic and altitude injury.

Technical Barrier #17: Immune System Enhancement

Soldiers may be threatened by many diseases (including AIDS). These diseases could be endemic to a geographical region or biological warfare agents, which may be either naturally occurring organisms causing known diseases or genetically-engineered organisms with unpredictable effects. Vaccines are effective, but very disease-specific, prophylactic treatments. Ways are needed to nonspecifically increase the resistance of soldiers to a wide variety of infectious organisms. Enhanced immune system function is an approach to this goal.

The USAMRIID and the WRAIR are investigating this approach through:

- Explorations of drugs to nonspecifically increase immune system activity, and
- Studies on basic mechanisms of immune system activation.

Technical Barrier #18: Neuroscience of Psychological Stress

Soldiers are exposed to a variety of psychological stresses affecting their performance. These include the different combat stresses in high- and low-intensity conflicts, sleep deprivation or fragmented sleep, jet lag from long deployments, and non-combat stresses associated with military life. Ways to prevent or minimize the adverse effects of these stresses, and treatments for the stress casualty are needed. The approaches may include leadership and training methods, doctrine modifications, drugs, and therapies. However, there is presently a limited science base to support rational development of any of these approaches. Neuroscience technologies offer great promise for effective military stress management by integration of information from the fields of neurochemistry, neurophysiology and psychology.

The WRAIR and the USARIEM are addressing this problem through:

- Studies on neurochemical, hormonal, and immunological responses to stress,
- Evaluation of pharmacological prevention of jet lag,
- Laboratory and operational studies of sleep and alertness during continuous and sustained operations,

- Evaluation of work/rest cycles in computer models of military unit performance, and
- Field research on prevention and treatment of combat psychiatric casualties during major military training operations.

Technical Barrier #19: Optimization of Fitness Training and Nutrition

The complex interactions among optimal fitness to perform a military assignment, and training methods and nutrition to maintain that level of fitness, are difficult to elucidate. Optimal training procedures and nutritional requirements will vary with task, environmental conditions, and other stresses. An additional complication associated with field nutrition is the necessity for stability and portability of field rations.

To address these issues, the USARIEM is conducting:

- Studies on factors that may help reduce the incidence and severity of training injuries,
- Investigations of physical fitness requirements and their relationship to job performance,
- Research on nutritional strategies to enhance psychological and military task performance,
- Evaluation of a nutrient solution for an NBC environment,
- Determinations of nutritional standards for operational rations, and
- Efforts to promote peacetime soldier wellness by minimizing nutritionally inadequate dietary regimes.

Technical Barrier #20: Protection Against Directed Energy Sources

Medical protection against the effects of directed energy weapons is a critical need for the current and future battlefield environment. Exposure to directed energy sources can occur while operating modern weapon systems as well as from enemy fire. Protective devices or other approaches are particularly needed for frequency-agile laser sources and high-energy, short pulse microwaves. Current laser protective eyewear is for low energy laser sources of restricted wavelength.

The LAIR and the WRAIR are responding to this barrier with:

- Studies on the cellular, biochemical, and physiological changes resulting from exposure to laser threats,
- Evaluation of health hazards associated with low-intensity continuous microwave exposure and high-energy short-pulse microwave systems,
- Studies of "natural" tissue protection against directed energy, and
- Assessments of the following technologies for laser eye protection: Bugate filters, fast-acting optical switches, eye-centered holography, absorptive chromophores, and polymeric layering.

FUTURE DIRECTIONS

"Future direction" encompasses the USAMRDC research aim to identify the medical requirements for conserving the fighting strength of today's soldiers and, at the same time, to work toward meeting our national strategic objectives for the next 10 to 20 years. Future direction within USAMRDC research program areas is generically discussed below. The projected availability dates for future medical products are shown in Table VI-1.

Table VI-1. Projected Availability Dates for Future Medical Products

1990	M291 Skin Decontaminating Kit
1991	Convulsant Antidote for Nerve Agents
1991	SIPE Assessment
1992	Field Feeding System Evaluation
1992	Smokes Assessment
1993	Field Medical Oxygen Generation and Distribution System
1993	X-ray System, Dental, Miniature
1993	Sleep-Inducing Drug for Deployment
1993	Ribavirin
1994	Resuscitation Fluids Production System
1994	Hypertonic Saline Dextran
1994	Computerized Tomography (CT) Scanner, Field
1994	Rapid Identification System
1995	Oxygen Carrying Blood Expanders
1997	Antimicrobial Dermal Dressing
1997	Skin Protectant, Topical
1998	Cyanide Pretreatment
1998	Improved Nerve Agent Antidote Kit
1999	Malaria Vaccine (Plasmodium falciparum, merozoite)
2002	Broad-spectrum Presynaptic Antitoxin
2002	Typhus Group Vaccine

Military Disease Hazards

Infectious Disease. The future direction of the Infectious Disease Research Program area includes exploiting biotechnology to develop prophylaxes, vaccines, drug/vaccine delivery systems, diagnostic tests, and treatment materiel against infectious diseases to reduce their impact on warfighting capability (i.e., 60-90 percent of all hospital admissions in all previous wars and conflicts), while continuing to develop traditional preventive technologies (i.e., vector control and field sanitation). Emphasis will be on planning, programming, and budgeting to sustain the DoD vaccine and drug industrial base. Consideration will be given to alternative drug delivery systems or vaccines that can be administered on a less-than-daily or weekly basis, so that continual protection will be provided with minimal or no sustaining treatments.

Medical Biological Defense. The future direction of the Medical Biological Defense Research Program area includes exploring generic approaches to prevention and treatment to reduce the burdens on health services and medical logistics, in addition to conserving the fighting forces. Biotechnology will be exploited to develop prophylaxes, vaccines, drug-vaccine delivery systems, and rapid-diagnostic tests for biological warfare threats, and to develop medical materiel to treat biological warfare casualties (Figure VI-19). Emphasis will be placed on planning, programming, and budgeting to sustain the DoD vaccine and drug industrial base. Research efforts should lead to the development of immunological carriers for transport of immunogenic peptides, vectored vaccines with multiple immunogenic properties, the capability to stimulate B- or T-cell's independently or simultaneously, and prophylactic or therapeutic approaches to block the actions of toxins and PACs on target receptor sites.

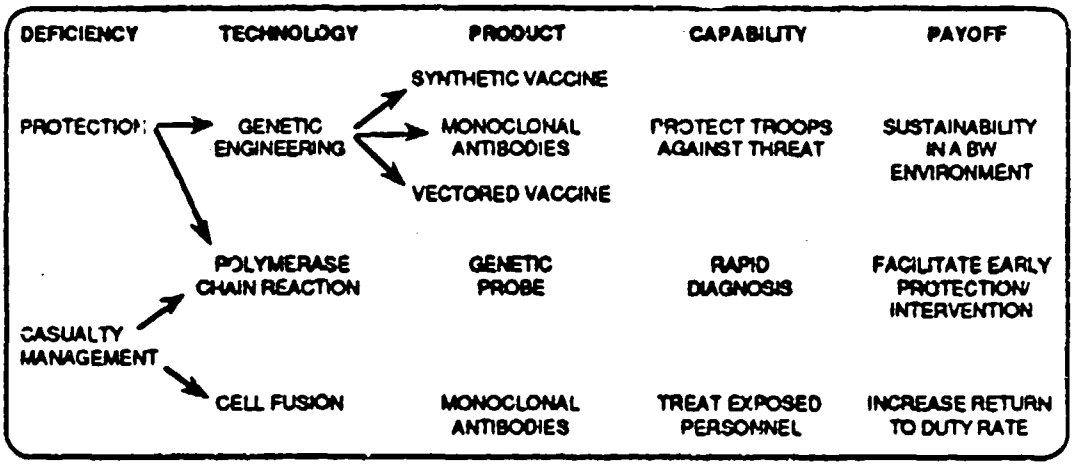


Figure VI-19. Application of Biotechnology to Counter Biological Threats

Military AIDS Research. The Army will maintain its lead role in conducting the separate, Congressionally directed, Military AIDS Research Program which deals with the prevention and treatment of infection with human immunodeficiency viruses. Established screening programs in Military Examining Processing Stations (MEPS) will continue toward the goal of detecting disease in Armed Forces accessions and minimizing the cost of HIV infections to the DoD. Priorities will continue to be: to evaluate the course of infection in military populations to aid in defining DoD policies; to identify risk factors (including OCONUS) important to troop education and AIDS virus transmission in military populations; to develop an efficient, high-quality, affordable screening program; and, to test and evaluate vaccines and drugs for protection and early intervention. Military and national programs in AIDS research are complementary, not duplicative, as shown in Figure VI-20.

	MILITARY	NATIONAL
FOCUS:	Detection, prevention and early intervention	Treatment/education of civilians
PROGRAMS		
Screening	Mandatory	Voluntary
Diagnosis	Early stage	Clinical stage
Natural History	Yes	None
Epidemiology	Infection	Disease
Chemotherapy	Prophylaxis	Therapy
Vaccines	Test and evaluation	Basic research and development
Blood Program	Rapid field	Time-insensitive
Data Base	Unique and comprehensive military	Sporadic and varied

Figure VI-20. Focus of Military and National Programs in AIDS Research

Medical Chemical Defense

The future direction of the Medical Chemical Defense Research Program area includes maximizing the development of prophylaxes, pretreatments, antidotes, and skin decontaminants/protectants, including novel delivery systems effective against known and emerging chemical threats, and production of medical materiel required to treat chemical warfare casualties. Advances in the neurosciences and biotechnology will be exploited to reduce incapacitation and/or performance degradation caused by threat agents or associated medical countermeasures. Modeling of medical research and development and information products using standard Army models and empirical data will provide an accurate assessment of impacts on the warfighting mission. Planning, programming, and budgeting will sustain the DoD pharmaceutical industrial base. Medical chemical countermeasures should provide protection against vesicant and emerging pulmonary threat agents; new generation pretreatments and antidotes should minimize human performance decrements; and generic approaches should be in development to reduce the burdens on health services and logistic support, as well as to conserve fighting strength.

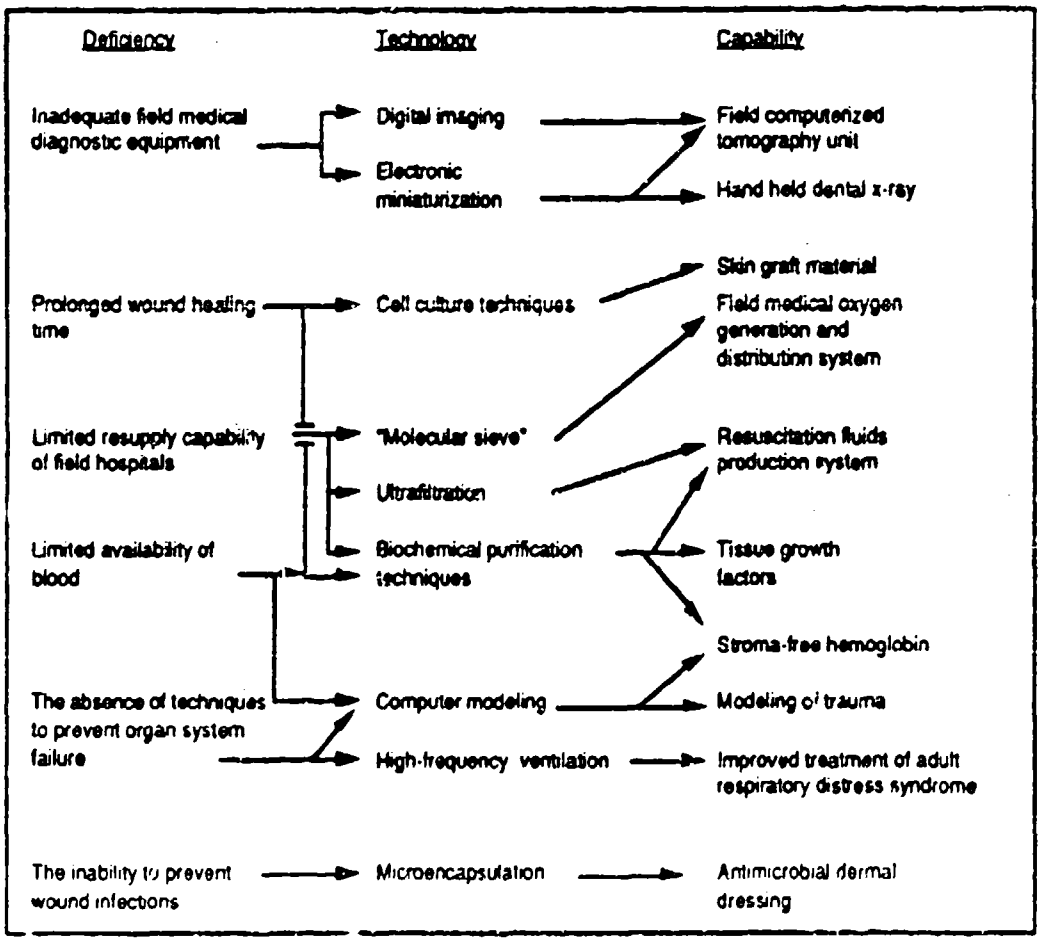


Figure VI-21. Application of Technology to Combat Casualty Care

Combat Casualty Care

The future direction of the Combat Casualty Care Research Program area includes: exploiting technological breakthroughs to enhance survivability and return-to-duty to conserve trained manpower; developing improved methods and equipment to reduce morbidity and mortality caused by novel weapon systems (e.g., directed energy and high-fragmentation devices), and to reduce delays in evacuating wounded to corps-level facilities due to isolation on a high-mobility battlefield; and developing next-generation diagnostic/treatment methods (e.g., filmless radiography and digital imaging networks) and materiel for shock, trauma, environmental hazards, wounds, and burns to enhance the rate of return-to-duty. Figure VI-21 projects the application of technological breakthroughs.

In addition, equipment and technology to match the training and capabilities of the health services personnel on the battlefield will be necessary. Combat casualty care technology will include synthetic oxygen-carrying blood substitutes, artificial skin, biodegradable tissue and bone replacements, and electromagnetically enhanced wound healing.

Combat dentistry will exploit technology to rapidly diagnose, treat, and sustain personnel against the impact of combat maxillofacial injuries, thus enhancing the rate of return-to-duty. The treatment of most combat maxillofacial injuries will be accomplished within the theater of operations. Surgical procedures will be reduced through the development of new technologies, thus expediting the rate of return-to-duty.

Systems Hazards

The future direction of the Systems Hazards Research Program area includes developing a comprehensive data base on environmental/Army systems health hazards and physiological/psychological limits of human endurance to support the integration of manpower and materiel in Army systems. Program guidance recommends that consideration be given to control criteria, engineering design, and appropriate strategies to reduce the effects of combat stress, sensory overload, and toxic fumes, as well as the effects of environmental hazards such as heat, cold, and altitude. Technologies will be pursued to support development of materiel to prevent injury due to electromagnetic/mechanical forces, including laser, high-power microwave, and blast overpressure. Products and strategies will be developed to reduce the effects of sleep deprivation or inadequate nutrition or hydration. Resources will be exploited to supply commanders with information products and decision support tools of human performance limitations/decrements and enhancements. This program will provide the materiel and information products to support dramatic increases in human performance capabilities in the high-stress environment of the battlefield.

Annex A

COMMERCIAL AND MILITARY R&D INVESTMENT STRATEGIES

The Army's and industry's R&D investment strategies differ because the military and commercial sectors support different goals and require different returns on their investments. For the military, the requirements are designed to address warfighting needs; the development and production costs are driven by the anticipated harsh use and the special circumstances of war. In the commercial sector, the civilian marketplace influences the need; the quantities required and the costs of development and production are the primary determinants of profit potential -- specialty needs are secondary. Thus, products developed for military requirements must support the special needs of warfighting; products developed for the commercial sector must return a profit in order to meet the expectations of the stockholders.

Because the specialized medical products required by the military often offer too little a profit potential to spur commercial R&D investment, a unique, Army-funded and -operated R&D program is needed. For example, most disease threats of military significance are not threats inside the continental U.S.; thus, commercial firms have no large profit incentive to undertake risky and expensive R&D programs for applicable drugs and vaccines. Moreover, countermeasures to other military health threats, such as biological or chemical warfare agents, are not germane to the civilian marketplace.

Commercial involvement in military medical products -- such as a drug or vaccine -- usually occurs after the military has underwritten the expense of preliminary research and development and can offer a low-risk developmental product that has some profit potential either overseas or in a small segment of the U.S. marketplace. Whenever possible, the Army capitalizes on these overlapping interests and, through Commercial Research and Development Agreements, sets up military/civilian sharing of final development costs. Nevertheless, the most risky portion of the development process, basic and exploratory research, remains a predominantly Army endeavor.

Figure A-1 compares the differing factors that shape military and commercial drug development programs. Differences seen in this area of medical R&D are representative of differences in other medical programs. Figure A-2 depicts the relative success rates for the Army's and industry's candidate drugs. Figure A-3 depicts the effect these two sets of data have on investment patterns in Army and industry drug development.

In constructing the Army versus industry cost comparisons in Figure A-3, it was necessary to estimate industry costs that were "out-of-pocket" (or free from "cost-of-money") figures which inflate industry costs relative to Army costs. The simplest way to compute total "out-of-pocket" costs was to divide the total R&D costs per year by that year's number of approved new drugs. This method has the advantage of capturing all costs, whether for successful or unsuccessful candidates. Based on data from the Pharmaceutical Manufacturers Association, the total investment in R&D for 1988 was $6.5 billion and the number of approved new drugs was 20, which gives an estimate of $325 million per new drug. However, this method of estimation is complicated by the fact that the primary expense of developing the drugs approved in 1988 was incurred 2-3 years previously due to the review cycle of the FDA once data is collected. Taking this review cycle "lag" into account, the five-year average of the R&D investment from 1982-1986 divided by the average number of products approved from 1984-1988 gives the more accurate estimate of $169 million per new drug. This estimate is uncorrected for inflation; when a 4 per cent average inflation rate from 1984, the midpoint of the investment series, is factored into the equation, the result is $190 million per drug in 1988 dollars, which is the estimate used in Figure A-3.

US Army R= 80%, D= 20%	Industry R= 55%, D= 45%
• Threat and Requirements Driven	• Market and Profit Driven
- Cannot Choose the Problem	- Can Choose Low Risk Problems
- Competitive Resourcing	- Committed Resourcing
- Self-Aid/Buddy-Aid	- Physician Supervision
• Problems are Army Specific	• Problems are National Health Concerns
- Chem/Bio Threats	- Hypertension
- Mil Disease Hazards	- Analgesics
• Required Tech Base is Army Unique	• Draws on National Tech Base
- Army Resources	- Public & Private Resources
- Sole Responsible Agency	- Multiple Parallel Programs
- Exploits National Tech Base	
• Focus on Threat	• Can Begin with Drug Design or Compound Reformulation
- Threat Mechanism	
- Drug Discovery and Drug Design	
• Relatively Small Manufacturing and Distribution Components	• Major Manufacturing and Marketing Components
• Constrained Clinical Trials (Phase III)	• Extensive Clinical Trials (Phase III)
• Contingency Fielding After Phase II	• NDA Approval Required for Distribution

Figure A-1: Comparison of Army and Industry Drug Research (R) and Development (D) Programs

	Drug Design & Discovery	Pre-clinical Studies	Phase I & II Clinical Trials	Phase III Clinical Trials NDA	Market/Field
Industry	4,000	100	5	2	1
Army					
Antimaterial	4,000	10	5	2	1
Ocime	1,000	5	3	*	1

* Army cannot conduct human efficacy trials against BW/CW threats

Reduces Development Cost by Down Selection in Research

Figure A-2: Notional Comparison of Army and Industry Candidate Drug Screening Throughput

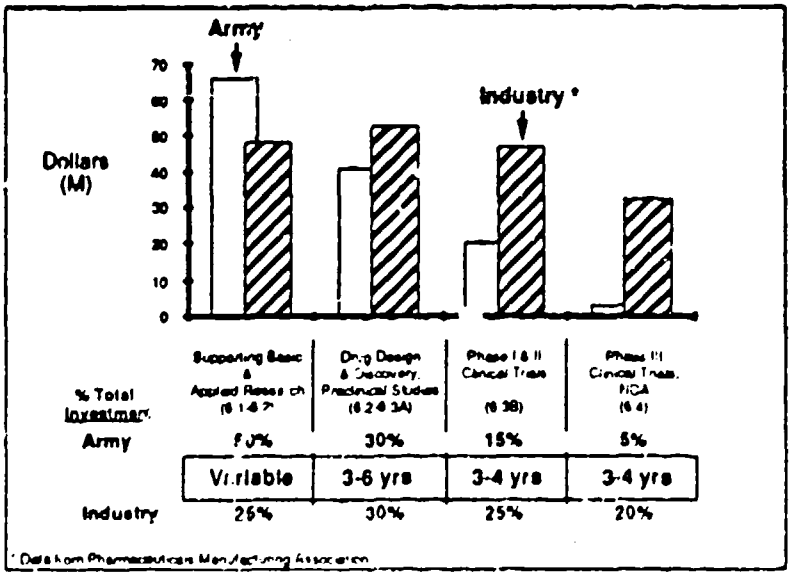


Figure A-3: Comparison of Army and Industry Drug R&D Costs

To construct comparable Army costs by phase of research, the costs of 6.1 and 6.2 research attributable to each candidate drug entered into the Core Drug Program was estimated, and accurate data on expenditure in advanced and full-scale development -- provided by the U.S. Army Medical Materiel Development Activity -- was factored in. The costs of maintaining a Core Drug Program (6.3A) capable of providing sufficient data to transition two candidates per year to 6.3B were thoroughly reviewed. Costs of unsuccessful candidates were incorporated into the estimation by a calculation using screening throughput rates depicted in Figure A-2. The total of the development cost (in Figure 3, for comparison purposes, $130 million) could vary by 10-15 percent, depending on the perspective of the estimator.

These comparisons are not intended to argue that the Army develops drugs at lower cost than does industry, but to convey that the various factors shaping each sector's program have led, necessarily, to different investment patterns for military and commercial researchers. As discussed in Section I and reiterated in Figures A-1 and A-2, Army drugs are not required to be licensed (and, in some cases, cannot be licensed due to the lack of opportunity for Phase III clinical trials) before they can be made available for military purposes (i.e., contingency fielding). Industrial products, in contrast, must be licensed before a profit can be realized. Thus, the Army's requirements for investment in the clinical phase of drug development is smaller than industry's. However, as noted, the Army's basic research costs are higher than industry's because the Army addresses military threats and problems that industry does not.

In summary, the Army Medical R&D program has -- and needs to have -- a different investment strategy than is found in the industrial sector: it is working different problems from different starting points and toward different ends. Seen from this perspective, the Army medical R&D program can be considered quite cost effective compared to industrial programs. The uniformed scientists managing these programs -- and their military colleagues who would be deployed in time of war -- know the fighting requirements and are best able to shape and focus the products to the needs of the battlefield environment.

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Annex B

WORLDWIDE DISTRIBUTION OF MILITARILY SIGNIFICANT DISEASES

The Army must assess the probable impact of disease on military forces and plan to utilize whatever countermeasures are, or are projected, to be available to lessen the impact of disease threats. It is imperative that the military Forces have in their armamentarium effective vaccines and drugs to counter the infectious and parasitic disease threats which exist in areas of strategic and military interest.

Using the available criteria and yardsticks, the military importance of specific diseases is judged as follows:

- Worldwide impact -- diarrheal disorders, hepatitis, skin disorders, venereal diseases.
- Principal impact in certain locations -- malaria, arbovirus, rickettsial disease, schistosomiasis, trypanosomiasis, leishmaniasis, and other parasitic diseases.
- Principal impact on certain populations or groups -- acute respiratory disease, dental caries, meningococcal disease.
- High epidemic potential -- arboviruses, rickettsial diseases.
- Special military situations -- defense against biological agents

Annex B includes Part I -- a tabulation of known or suspected specific disease distributions worldwide, and Part II -- the characteristics of specific disease threats. The characteristics of specific disease threats elaborate both on the problem and the military medical relationship. (Information has been extracted from the references cited at the end of Annex B.)

Part 1: Worldwide Geographical Distribution of Diseases
(See Reference 2, Annex B)

DISEASE	North America	Central America & Caribbean	South America	Sub-Saharan Africa	North Africa & Middle East	Central & South Asia	East Asia & Oceana	Europe
African Trypanosomiasis				X				
Amebiasis	X	X	X	X	X	X	X	
American Trypanosomiasis		X	X					
Ancylostomiasis	X	X	X	X	X	X	X	X
Anthrax		X	X	X	X	X	X	X
Argentine Hemorrhagic Fever			X					
Ascariasis	X	X	X	X	X	X	X	X
Bartonellosis			X					
Blastomycosis	X	X	X	X	X			
Bolivian Hemorrhagic Fever			X					
Boutonneuse Fever				X	X	X		X
Brucellosis	X	X	X	X	X	X	X	X
Bunyamwera Fever				X				
Bwamba Fever				X				
California Encephalitis	X							
Campylobacteriosis	X	X	X	X	X	X	X	X
Central European Encephalitis								X
Chlamydial Infections	X	X	X	X	X	X	X	X
Chikungunya Fever				X		X	X	
Cholera				X	X	X	X	X
Coccidioidomycosis	X	X	X					
Congo-Crimean Hemorrhagic Fever				X	X	X		X
Cryptospordiosis	X	X	X	X	X	X	X	X

Part 1: Worldwide Geographical Distribution of Diseases (continued)

DISEASE	North America	Central America & Caribbean	South America	Sub-Saharan Africa	North Africa & Middle East	Central & South Asia	East Asia & Oceana	Europe
Dengue Fever		X	X	X		X	X	
Dengue Hemorrhagic Fever						X	X	
Eastern Equine Encephalitis	X	X	X					
Ebola Virus Disease				X				
Echinococcosis	X	X	X	X	X	X	X	X
Enterotoxigenic E. coli	X	X	X	X	X	X	X	X
Erlichiosis	X	X	X	X	X	X	X	X
Filariasis		X	X	X		X	X	
Giardiasis		X	X	X	X	X	X	X
Gonorrhea	X	X	X	X	X	X	X	X
Group C Fever		X	X					
Hemorrhagic Fever with Renal Syndrome (HFRS)							X	X
Hepatitis A	X	X	X	X	X	X	X	X
Hepatitis B	X	X	X	X	X	X	X	X
Hepatitis Non A Non B	X	X	X	X	X	X	X	X
Histoplasmosis	X	X	X	X	X	X	X	X
HIV/AIDS	X	X	X	X	X	X	X	X
Ileus		X	X					
Japanese B Encephalitis						X	X	
Kyasanur Forest Disease						X		
Lassa Fever				X				
Legionnaires Disease	X	X	X	X	X	X	X	X
Leishmaniasis (Cutaneous)		X	X	X	X	X		X

Part 1: Worldwide Geographical Distribution of Diseases (continued)

DISEASE	North America	Central America & Caribbean	South America	Sub-Saharan Africa	North Africa & Middle East	Central & South Asia	East Asia & Oceania	Europe
Leishmaniasis (Visceral)		X	X	X	X	X	X	X
Leptospirosis	X	X	X	X	X	X	X	X
Loiasis				X				
Louping III								X
Lyme Disease	X							X
Malaria		X	X	X	X	X	X	X (Turkey)
Marburg Virus Disease				X				
Mayaro		X	X					
Melioidosis		X	X				X	X (Turkey)
Meningococcal Meningitis	X	X	X	X	X	X	X	X
Murray Valley Encephalitis							X	
Omsk Hemorrhagic Fever						X		
Onchocerciasis		X	X	X				
O'Nyong-Nyong				X				
Oropouche			X					
Phlebotomus Fever		X	X	X	X	X		X
Plague	X		X	X	X	X	X	
Powassan Encephalitis	X							
Psittacosis	X	X	X	X	X	X	X	X
Q-Fever		X	X	X	X	X	X	X
Rabies	X	X	X	X	X	X	X	X
Relapsing Fever (louse-borne)			X	X	X	X	X	X

Part 1: Worldwide Geographical Distribution of Diseases (continued)

DISEASE	North America	Central America & Caribbean	South America	Sub-Saharan Africa	North Africa & Middle East	Central & South Asia	East Asia & Oceana	Europe
Relapsing Fever (tick-borne)	X	X	X	X	X	X	X	X
Rift Valley Fever				X				
Rota Viral Agents	X	X	X	X	X	X	X	X
Russian Spring-Summer Encephalitis					X	X		X
Salmonellosis	X	X	X	X	X	X	X	X
Schistosomiasis		X	X	X	X	X	X	
Sindbis Fever				X	X	X	X	
St. Louis Encephalitis	X	X	X					
Syphilis	X	X	X	X	X	X	X	X
Taeniasis		X	X	X	X	X	X	X
Toxic Shock	X	X	X	X	X	X	X	X
Trachoma			X	X	X	X	X	X
Tularemia	X	X	X	X		X		X
Typhoid & Paratyphoid Fever	X	X	X	X	X	X	X	X
Typhus (flea-borne)	X	X	X	X	X	X	X	X
Typhus (louse-borne)		X	X	X	X	X	X	X
Typhus (mite-borne)						X	X	
Venezuelan Equine Fever			X					
West Nile Fever				X	X	X		
Western Equine Encephalitis	X							
Yellow Fever			X	X				

Part 2: Diseases of Military Significance (See Reference 1, Annex B)

ACUTE RESI ...SEASE

Problem. Viral respiratory infections cause fever with sore throats, muscle aches and occasionally pneumonia. The principal causes of acute respiratory disease (ARD) are adenoviruses during basic training and influenza at other times. ARD has been substantially reduced since the introduction of adenovirus types 4 and 7 vaccines and annual influenza immunization. However, the emergence of new strains of influenza and adenovirus may lead to epidemics in military personnel.

Military Medical Relationships. ARD due to adenovirus infections has been reported on European, Indian, Russian and Canadian training posts as well as in all three U.S. services.

During the 1960s nearly 50% of basic trainees on Northern posts required hospitalization for ARD during the 8 weeks of basic training. This represented hospitalization rates of 6-8/1000 man/week and caused substantial difficulty in terms of disrupted training schedules and overtaxed medical resources. Combined use of live oral enteric coated adenovirus types 4 and 7 vaccines developed by Walter Reed Army Institute of Research reduced ARD rates by 50% and adenovirus ARD rates by 95%; these vaccines, licensed by the FDA have been effectively used on all US training posts since 1971.

In 1972, influenza A incapacitated over 60% of Air Force pilots at a base in Thailand in one week, significantly hindering combat operations.

In 1917, influenza attacked over 30% of all Army enlisted personnel and killed one of every 100 Army enlisted men.

ACUTE DIARRHEAL DISEASES
BACILLARY DYSENTERY (SHIGELLOSIS) AND TRAVELER'S DIARRHEA

Problem. Bacillary dysentery is caused by a bacterial infection of the cells which line the large intestine. The organisms (shigella bacteria) enter by the oral route in contaminated food and water or by exposure to infected individuals. As few as ten bacteria can cause clinical illness. The disease is characterized by bloody diarrhea, cramps, fever and prostration. The disease occurs worldwide with the highest incidence in underdeveloped countries. Neither antibiotics or injected vaccines have been successful in preventing shigellosis. On the other hand, living-attenuated oral prototype vaccines show promise of efficacy, but have not been developed to the point where they are practical. Antibiotics are effective in treating bacillary dysentery, but their effect is not dramatic -- only reducing the average time of illness from five down to three days. Multiple drug resistance of many dysentery organisms frequently complicates treatment.

Traveler's diarrhea is a term used to describe diarrheal illness experienced by individuals traveling from one country to another. Lately some *E. coli* strains (previously thought to be innocuous) have been found responsible for a significant portion of this disease. The organism causes a watery diarrhea by attaching to the small intestine and producing a toxin(s) which causes the small intestine to secrete excessive fluid. Neither vaccines nor drugs are presently available to prevent this illness. The organisms may be sensitive to a variety of antibiotics, but the disease, although acutely severe, is usually too short-lived for the drugs to be effective.

Military Medical Relationships. Bacillary dysentery has been a component of military campaigns since biblical times and is a major public health problem in most parts of the world. In recent history, it was as important in causing the British defeat at Gallipoli as the decisions made by British military leaders. Shigellosis caused significant illness in American troops ...with Africa, the South Pacific, in Korea and

was responsible for virtually all of the morbidity during our 1958 incursion into Lebanon. During the Vietnam conflict, forty percent of the diarrhea in U.S. forces was caused by dysentery bacilli.

The incidence of *E. coli* (Traveler's) diarrhea in military operations was not known prior to 1969. Approximately twenty percent of the diarrhea occurring in American troops in Vietnam was due to these pathogenic *E. coli* strains.

MALARIA

Problem. Malaria continues to be among the leading causes of disease in the world; it occurs from 45 degrees north to 45 degrees south latitude including Asia, the Middle East, Latin America and Africa. After initial successes in subtropical areas in the 1950s, World Health Organization (WHO) worldwide malaria eradication programs began to fail in the 1960s due to emerging resistance of mosquitoes to insecticides and resistance of malaria parasites to drugs. Currently, malaria is resurgent throughout the tropics and is epidemic in many countries, including India and Turkey, where it had been previously controlled.

Malaria is caused by infection of red blood cells with parasites transmitted by anopheline mosquitoes. The disease is severely debilitating, with recurrent high fever and anemia, and falciparum malaria, the most severe form, is often fatal if untreated.

Most falciparum malarias in Asia and South America are currently resistant to all standard oral drugs (chloroquine and fansidar) excepting quinine. However, an effective drug for prevention or treatment of falciparum malaria is the developed and recently licensed drug, Mefloquine, from the Walter Reed Army Institute of Research Drug Development Program.

Military Medical Relationships. Malaria has caused epidemic disease in combat forces in previous wars; its recent resurgence and increasing resistance to available drugs suggest that past history will be repeated. In the Macedonian campaign in WW I, malaria immobilized British, French and German Armies for 3 years. Nearly 80% of the French Troops were hospitalized; the British Army hospitalized 160,000 troops for malaria compared to 23,000 battle casualties. In Guadalcanal in 1942, there were 100,000 cases of malaria in 8 months, and 5 times as many malaria casualties as wound casualties. In Vietnam, there were over 80,000 U.S. malaria casualties in spite of intensive preventive measures. Well over 1 million man-days were lost and evacuations for malaria often equaled evacuations for wounds.

CHIKUNGUNYA, RIFT VALLEY FEVER AND OTHER ARBOVIRUSES

Problem. Several arthropod-borne viruses produce severe epidemics of acute febrile illness. These illnesses may be severe (hemorrhagic fevers, encephalitis) or self limiting febrile illness with joint pains and rash. Chikungunya virus has caused devastating epidemics involving millions of people in Africa, South Asia and Southeast Asia. Rift Valley Fever causes devastating epizootic disease in domestic sheep and cattle and spreads to man causing a severe illness with hemorrhagic and ocular manifestations. Other African arboviruses, West Nile Fever, O'Nyong-Nyong, have apparently lesser epidemic potential. In South America, Mayaro virus and Oropouche viruses cause epidemics of acute febrile illness. Viral encephalitides such as Japanese B encephalitis virus cause much smaller numbers of cases but case fatality and permanent disability rates are very high. All of these agents are mosquito-borne and vaccines are available for Rift Valley Fever, Japanese B encephalitis, Eastern and Western encephalitis, and Chikungunya, in addition, vector control and avoidance are appropriate means of disease control.

Military Medical Relationships. Chikungunya virus was a cause of an unknown but probably significant number of acute febrile illnesses in Vietnam. Japanese encephalitis has caused serious local epidemics in U.S. Forces in Okinawa, Korea and Thailand. Approximately 200 cases per year occurred among U.S. Forces during the Vietnam conflict.

DENGUE

Problem. Dengue is an epidemic viral illness of acute onset with fever, headache, severe muscle pain and frequently a rash. Dengue fever is caused by any of four types of viruses identified as dengue types 1, 2, 3, and 4, each of which is capable of causing disabling epidemics. Dengue fever is found in all tropical areas where the *Aedes aegypti* mosquito vector is located. Although in most regions dengue fever is associated with low frequency of complications, children in Southeast Asia experience a hemorrhagic fever and shock syndrome which is fatal in 5% of cases. The only presently available means of dengue control is eradication of the mosquito vector. More effective disease control is expected by use of a live virus vaccine.

Military Medical Relationships. Dengue fever is endemic and epidemic in many parts of the world. During WW II, with the movement of large numbers of troops into the South Pacific, the effect of dengue soon became apparent. Between 1942-1945, the U.S. Army experienced over 90,000 recorded cases of dengue fever. The highest attack rates occurred in New Guinea where in some islands dengue cases outnumbered malaria by four to one. Attack rates peaked at 1% per day in Saipan in 1944.

Forty of the first 48 military personnel occupying the airfield at Hang Kow, China immediately after V-J day developed dengue fever within 10 days

During the Vietnam conflict, dengue was the leading cause of febrile disease in troops assigned to urban areas.

In 1977-1978 an epidemic of dengue type 1 spread throughout the Caribbean with reported attack rates of 6.9%-16.5% in work force age groups.

Less than 1% of U.S. residents are immune to dengue when they begin military service

HEMORRHAGIC FEVERS

Problem. Several viruses which are maintained in nature in small vertebrate hosts such as rodents can cause severe acute febrile illnesses in man with major hemorrhagic manifestation, multiple organ involvement and significant case fatality rates. Epidemics of these highly infectious agents cause major problems in patient care because of danger to close contact and medical personnel. Three arenaviruses, Machupo virus, Junin virus and Lassa fever virus are the causative agents of epidemic hemorrhagic fevers in Bolivia, Argentina and West Africa, respectively. Case fatality rates up to 20 percent have occurred with these viruses. Two recognized rhabdoviruses, Marburg virus and Ebola virus, caused severe illnesses in Central, East and South Africa. In an outbreak of Ebola virus in Zaire, 90 percent fatalities occurred. The reservoirs of these agents are unknown. Korean hemorrhagic fever virus and other closely related viruses cause hemorrhagic renal syndrome from Scandinavia to Japan. Outbreaks of Far Eastern or Korean hemorrhagic fever occur annually in China, USSR, and Korea with widespread occurrence of severe disease, the reservoir is wild field rodents. In 1986, 10 marines in a unit training exercise in Korea developed Korean hemorrhagic fever and two died

Military Medical Relationship. Epidemics of Korean hemorrhagic fever severely affected U.S. troops during the Korean conflict, approximately 3,500 cases occurred in the first 5 months. Because of disease severity, a special Army hospital was established in Pusan. Korean hemorrhagic fever is widespread in Asia and because of its transmission by field rodents is a special hazard to troops in the field under combat conditions.

Lassa fever is widespread in West and Central Africa

SCRUB TYPHUS

Problem. Scrub typhus is an infectious disease caused by *Rickettsia tsutsugamushi* and transmitted to man by mites. It is absolutely distinct from two other rickettsial diseases, typhus and murine typhus, in disease severity, method of transmission and geography. The incubation period of the disease is about 10-12 days. Illness begins suddenly with fever, chilliness and severe headache. In untreated or misdiagnosed patients, illness persists for 2-3 weeks, leads to death in 5% of the cases and is followed by a prolonged convalescence. Antibiotic therapy with tetracycline or its derivatives is effective, but must be continued for approximately two weeks to preclude recrudescence of infection.

Military Medical Relationships. Over 18,000 casualties in allied troops were attributable to scrub typhus during World War II. Scrub typhus was second only to malaria as a cause of hospitalizations for infectious disease among combat troops in Vietnam.

Casualties have been reported by allied field units operating in Malaya, New Guinea, Korea, Philippine Islands, India, China, Burma, Thailand, Vietnam and Japan. The geographical area of potential infection, where scrub typhus is known to occur, is much larger and extends from Japan to Australia to West Pakistan.

SCHISTOSOMIASIS

Problem. Next to malaria, schistosomiasis is the parasitic disease causing the greatest morbidity and mortality in tropical and subtropical regions. WHO estimates that there are 180-200 million cases of schistosomiasis worldwide.

The parasitic worms which cause schistosomiasis in man and domestic animals are digenetic trematodes or flukes. Three species are commonly parasitic to man. Eggs produced by the female worms are voided by man in the feces or urine. Upon hatching, the larvae penetrate certain aquatic snails, undergo asexual reproduction, and are liberated into water as cercariae. The cercariae will rapidly penetrate the skin of individuals coming in contact with infested waters, enter the peripheral venous or lymphatic vessels, move to the lungs via the heart and then migrate to the vessels of the intestine or bladder where maturation, mating and egg laying takes place. Five to six weeks are required from the time of skin penetration until the egg laying takes place.

Initial signs of infection, associated with the migratory stage of the parasite are a non-productive cough and spiking fever of 38.9 to 40 degrees C (102-104 degrees F) first appearing 3 weeks after exposure and lasting from one to eight weeks. Subsequent development of the parasite produces long-term disability resulting principally from lesions of the hepato-splenic and intestinal organ systems. The schistosome eggs are the predominant cause of the disease as seen in man. While primarily affecting liver, spleen, intestine and bladder, they may be distributed throughout the body of the host and lodge in virtually all tissue blocking circulation and producing foreign body reactions. Individuals may remain infected for years - undernourished, underdeveloped and chronically ill.

Military Medical Relationship. Schistosomiasis infected 625 British troops in the Boer War and reportedly stopped the planned invasion of Taiwan in early 1950 by the Army of Mao Tse-tung. In the latter instance, the Communist troops trained for the planned amphibious attack by giving intensive [illegible] training in southern Chekiang and northern Fukien which were laced with cercaria infested canals. The resulting epidemic of schistosomiasis struck an estimated 30,000 to 50,000 troops, aborting the [illegible]. By June of 1950, the Korean War had begun and the U.S. Seventh Fleet was in the Formosa [illegible] thus discouraging any future amphibious operation.

Should the global commitments of the United States require deployment of military forces into areas endemic for schistosomiasis, the risk of infection would be high, particularly for the foot soldier. World War II experience shows that development of the disease would result in significant manpower loss and long term commitment of extensive medical resources. The invasion of Leyte in 1944 indicates what can happen if forces are committed in an endemic area for even a short period of time. The Army accumulated approximately 1700 cases; U.S. Naval and Australian Air Force personnel were also affected. The highest incidence of infection was seen in engineer and infantry units. Attack rates for engineers exposed to water while constructing bridges were 71 to 89%.

LEISHMANIASIS

Problem. Leishmaniasis is a parasitic disease which is common throughout many of the tropical and subtropical areas of the world. The Leishmania parasites are transmitted by the bite of tiny sandflies of the genus *Phlebotomus* or *Lutzomyia*, and the parasites infect human cells called macrophages.

Leishmaniasis appears in 3 different clinical forms: visceral, mucocutaneous and cutaneous. Visceral leishmaniasis causes widespread infection of macrophages throughout the body and, untreated, is fatal in 98% of cases; this form is widespread in Africa, the Middle East and Asia. Mucocutaneous leishmaniasis produces chronic skin lesions resembling leprosy, followed by horribly disfiguring erosion of the nose and mouth: it occurs throughout South and Central America. Cutaneous leishmaniasis causes persistent and disfiguring ulcers of the skin, and is prevalent in the Middle East, SW Asia and South and Central America.

No vaccines or drugs are available to prevent leishmaniasis. One drug, Pentostam, is licensed for therapy of leishmaniasis; it is toxic to the heart and kidneys and not fully effective in treating cutaneous, mucocutaneous or visceral leishmaniasis at tolerable doses. Pentostam-resistant leishmaniasis exists in Africa, and could exist in other regions as well.

Military Medical Relationship. In WW II, cutaneous leishmaniasis was common in the Persian Gulf Command where it attacked 5% of troops during the 3 peak months; the number of individual skin lesions varied from 1 to 29 with an average of 4 per patient. Also, 50 to 75 cases of visceral leishmaniasis occurred in U.S. military personnel in the Mediterranean basin and India.

U.S. Army cases number over 300 since 1955. Nearly all have occurred during jungle warfare training in P. ama.

AFRICAN TRYPANOSOMIASIS

Problem. Parasitic trypanosomes produce sleeping sickness in man in Africa where trypanosome infection in domestic cattle is a major economic problem. There have been intensive efforts to control or eradicate trypanosomiasis in Africa for 70 years by eliminating the tsetse fly which transmits the disease. Limited control has been achieved during periods of political tranquility, but there have been repeated epidemics when fly control is relaxed. In epidemics, up to 10% of the human population have died.

In man, after the bite of an infected fly, the trypanosomes rapidly infect the blood, causing repeated attacks of fever, anemia, involvement of the heart and lymph glands and severe disability. Weeks or months later, the trypanosomes invade the brain, causing neurologic disorders, including the characteristic drowsiness and eventually coma. Neurological trypanosomiasis is nearly 100% fatal if untreated.

A number of drugs, including arsenicals, diamidines and Suramin are currently used to treat early blood-stage trypanosomiasis. While early treatment is often effective, all of these drugs are extremely toxic, and may cause permanent damage, including heart, kidney, liver and pancreatic failure. Treatment of trypanosomiasis, once the brain is infected, is much less satisfactory. Only arsenicals enter the brain

and cure the disease and the risk of fatal heart toxicity and permanent nerve and brain damage, including blindness, is high.

No vaccines exist for protection of exposed individuals and none of the drugs used in therapy are safe enough for prophylactic use.

Resistance to all available drugs has been recognized.

Military Medical Relationship. To date, the U.S. Army has had no significant casualties due to African Trypanosomiasis in any war. If military operations in Africa were required, the U.S. Army is poorly equipped to prevent infection or to treat it. With disruption of fly control programs caused by wartime conditions, an epidemic situation seems inevitable; indeed the WHO estimates an increase in trypanosomiasis cases by 10,000 in Uganda in 1980 as the effect of political instability on control programs. Mobile operations mitigate against U.S. Forces re-establishing effective fly control measures.

GONORRHEA

Problem. Gonorrhea is a sexually transmitted disease which has reached epidemic proportions throughout most parts of the world. Approximately 3 million cases per year occur in the U.S. alone. It causes a great deal of morbidity, especially in young women, and results in considerable military ineffectiveness. In recent years the organism causing gonorrhea, the gonococcus, has become increasingly resistant to antibiotics and strains completely resistant to penicillin have now been isolated. Further development of gonococcal resistance to antibiotics may render outpatient therapy ineffective and necessitate a large number of hospitalizations for prolonged intravenous antibiotic therapy and create a significant problem of non-effectiveness in military populations.

Military Medical Relationships. The incidence of gonorrhea is highest in young adults between the ages 18 and 30 years, the bulk of the military population. In some parts of the world where U.S. troops are stationed, attack rates of gonorrhea are 60% per year and it is estimated that up to 80% of enlisted troops will contract gonorrhea at least once during their tour of duty.

The highest prevalence of penicillin resistant gonococcal strains occur in those parts of the world where military troops are stationed. For example, greater than 65% of the gonococcal strains now being isolated in Subic Bay, Philippines are resistant to penicillin.

VIRAL HEPATITIS

Problem. Viral hepatitis is a disabling disease characterized by dark urine, abdominal pain, fever and jaundice which usually lasts 6-8 weeks but can lead to a prolonged infectious carrier state and chronic liver disease. Three groups of infectious agents which commonly cause hepatitis are hepatitis A, B and non-A, non-B viruses. Hepatitis A virus causes an acute illness of abrupt onset which is transmitted by fecal contamination of water, food or hands. It is the predominant cause of community hepatitis epidemics. Hepatitis B virus is present in the blood of infected persons and is transmitted by needles contaminated with blood, sexual contact and transfusions. Non-A, non-B hepatitis virus is now the leading cause of hepatitis following blood transfusion in the U.S. and has been reported to have caused several large water-borne epidemics of hepatitis in India. All forms of hepatitis are distributed worldwide but they are considered to be endemic in the tropics and underdeveloped countries. Hepatitis prevention is limited to passive immunization with immune serum globulin at the present time. Hepatitis B vaccines, developed by Merck and NIAID, are undergoing evaluation by the USAMRDC; the Merck vaccine appears effective in preventing hepatitis B in initial trials.

Military Medical Relationships. Acute icteric hepatitis has been a recurrent problem for armies throughout history. Approximately 182,000 cases occurred in the U.S. Armed Forces during WW II. Approximately 6,000 cases were reported during the Korean War and 2,000 cases per year in Southeast

Asia in 1968-1969. In 1974 over 4,500 cases were reported worldwide for the U.S. Army with the highest incidence rates being observed in Europe and Korea. In 1978-1979 it was determined that over 70% of Army cases were due to hepatitis B virus although hepatitis A and non-A, non-B contributed to the problem. Since 1976, hepatitis A epidemics among garrison troops have been associated with dependents attending child care centers on post with increasing frequency.

MENINGOCOCCAL DISEASE

Problem. The bacterium, *Neisseria meningitides*, causes severe, life-threatening illness in the form of meningitis (infection of the covering of the brain and spinal cord) or blood stream infection (septicemia); severe infections are fatal in 5 to 15% of cases in spite of prompt diagnosis and treatment. Meningococcal disease develops rapidly over a period of 24 hours or less. The attack rate is highest in children under 5 years of age and in young adults 15 to 25 years of age, especially in military recruit camps. Meningococci are classified into 8 different serogroups of which three (A,B and C) have been responsible for epidemics and have historically caused about 95% of all diseases. The minor serogroups, especially Y and W135 are, however, fully virulent and cause a significant amount of endemic disease. Effective vaccines against groups A and C were developed at the WRAIR in the late 1960s and are now routinely given to all military recruits. Over the past decade these vaccines have been used to control meningococcal epidemics in Finland, Brazil, Africa, and the United States. Outbreaks of meningococcal disease during WW II were controlled by prophylactic use of sulfa drugs; this method failed in 1962 because of the emergence of drug resistant strains and led to the closure of Fort Ord for military training because of epidemic meningitis.

Military Medical Relationships. Military recruits in basic training have a tenfold higher than normal risk of contracting meningococcal disease.

Epidemics of meningococcal disease in military recruits have often accompanied military mobilization. During WW II there was an epidemic of group A disease and during the Vietnam War there was an epidemic of group B disease which gradually shifted to group C disease. During that period there were 300-400 cases per year in Army recruits with about 10% case fatality rates.

Over the past 8 years (approximately 1973-1981) the incidence of meningococcal disease in Army recruits has been about 30 per year with 7% fatality. About half of the current disease is due to group B and half to groups Y and W135.

Meningococcal disease in the United States as a whole is currently on the increase.

Epidemics of group B disease have occurred recently in Norway, South Africa and Spain.

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Annex C

SYNOPSIS OF THE HEALTH SERVICES LONG-RANGE PLAN

The Army Long-Range Planning System is founded on the tenets of AirLand Battle Future (ALB-F) and other special and functional long range plans. The Health Services Long-Range Plan (HSLRP) is part of the Army Long-Range Planning System. These documents estimate the military and environmental threats to the Army as well as to the rest of the world, and country situations (e.g., demographics, economics, etc.) which may impact upon the Army's conduct of operations.

Of critical importance to the Army Medical Department (AMEDD) is the ability to develop its capabilities consistent with and parallel to those of other Army units. The AMEDD must be synchronized for all of the up and coming conceptual designs and materiel developments if it is to survive on the battlefield of the future. The transition period from our current doctrine in support of AirLand Battle (ALB) to that of AirLand Battle Future (ALB-F) must be well thought out and in synchronization with other Army initiatives.

The Army Long-Range Planning Guidance (ALRPG), in conjunction with the HSLRP, provides a framework for the development and execution of The Army Plan which translates long-range planning guidance into mid-range programs based on the Army's senior leadership guidance and external directives. As such, the HSLRP directly influences both the Program Objective Memorandum (POM) and the initiatives stated in the Long-Range Research Development and Acquisition Plan (LRRDAP).

GUIDING PRINCIPLES

To maintain continuity and develop future capabilities, Army leadership has established guiding principles in the ALRPG development. The HSLRP has adopted the following guiding principles:

a. Obtain quality soldiers for the AMEDD and provide a quality of life to them and their families to ensure mission success.

b. Develop all aspects of medical intelligence (collection, processing and fusion, production support, dissemination) to respond to peacetime, crisis, and wartime information requirements of combat developers, commanders, and policy makers.

c. Develop medical doctrine, training, force structure and materiel development to be compatible with combat, combat support (CS), and combat service support (CSS) features of smaller size, self-sustaining, and increased mobility to deal with low-, mid-, and high-intensity conflicts.

d. Integrate emerging technologies (biotechnology, neuroscience, microelectronics, artificial intelligence, robotics, opportunities offered by space operations, etc.) to optimize and sustain medical operations on the integrated battlefield to enhance survivability of soldiers and materiel.

e. Enhance the soldier's chances of survival for injuries received from conventional, NBC, and DE weapons; and endemic disease threats; and combined injuries. The main objectives are to prevent illness, maximize return-to-duty (RTD), address combat stress casualties, permit medical personnel to better manage and treat patients, and reduce weight and cube of medical materiel.

f. Minimize the time for mobilization and deployment of medical units.

g. Contingency forces must be thoroughly prepared to conduct and sustain joint and combined operations against increasingly capable regional operational forces.

h. The AMEDD must maximize rationalization, standardization, and interoperability with all of its allies (NATO, etc.) in terms of standard NATO agreements and Quadripartite standard agreements.

i. Optimize medical logistics to maximize stockpiling and preposition of medical materiel, industrial production in time of war, alternative production sources, and other considerations to ensure sustained medical operations.

j. Optimize host nation support.

LONG-RANGE MEDICAL GOALS

Health services as a special area consists of those services performed, provided, or arranged which promote, improve, conserve, or restore the mental or physical well-being of individuals or groups. The long range goals which are established to accomplish the health services objectives are stated as follows:

a. Improve battlefield casualty management and evacuation to speed the return of soldiers to duty. Improve flexibility, deployability, mobility, and sustainability of field medical units. Develop innovative means to minimize time from wounding to treatment and improve casualty survivability by acquiring improved medical evaluation transport and materiel to facilitate enroute treatment. Pursue medical technology that lightens the logistical load and enhances combat health care to mobilizing/deploying forces.

b. Exploit medical and other technology to minimize casualties, enhance survivability, and treatment on the integrated battlefield. Seek and exploit advances in health care that will improve preventive medicine techniques and enhance triage and treatment of soldiers. Continue research and development of new technologies, including biotechnology, to accelerate treatment and recovery of wounded, sick, and injured soldiers. Develop advanced vaccines, pretreatments, other prophylactic agents, and treatment methods against will be encountered on the integrated battlefield as well as endemic diseases; conventional; Nuclear Biological and Chemical (NBC); and directed energy (DE) weapons; and combined injury threats that will be encountered on the integrated battlefield.

c. Develop programs to deal with combat stress prevention and treatment. Specifically, be prepared to deal with combat stress brought on by combat that is faster-paced, more lethal and more terrifying than any experienced to date. In addition, be prepared to help commanders maintain morale and deal with the enduring frustrations of tightly drawn rules of engagement, protracted operations against elusive, irregular forces and related pressures associated with low-intensity conflict.

d. Maintain health services to eligible beneficiaries.

Areas of Consideration

The accomplishment of the cited goals is dependent upon realistic and achievable interpretation of the AMEDD's needs for the 21st Century. It is imperative that health services planners look to the past and present to gain an appreciation of the magnitude of change which can be expected in the health care delivery system for the future. Those areas which are expanded upon in the special and functional areas of the ALRPG, along with the six guiding principles for the Army form the basic framework of this plan. These areas are developed by the responsible OTSG staff office and include the areas listed below.

Structuring	Equipping	Manning	Sustaining
Training	Managing Resources	Mobilizing/Deploying	Intelligence
Providing Facilities	Medical Space	Managing Information	Medical Treatment

The primary functional area of interest to medical R&D is Equipping. This section of the HSLRP is reproduced in its entirety below.

EQUIPPING

Equipping the Army with medical materiel and critical military informational products to prevent or treat illness and injuries is the responsibility of the AMEDD. This process begins by defining the medical requirements for the soldier under realistic battlefield conditions. The process of defining the medical materiel requirements involves the U.S. Army Medical Research and Development Command (USAMRDC), Academy of Health Sciences (AHS) and the U.S. Army Training and Doctrine Command (TRADOC).

Equipping includes the research, development, acquisition, distribution, and combat development activities necessary to equip the force. It includes facilities support and industrial base support. These activities are based upon the perceived medical equipment requirements for the Army as they relate to the ALRPG, ALB-F, and other special/functional Army plans.

Army medical requirements are defined in large part through the Concept Based Requirements System (CBRS). Within CBRS, concepts that describe the future battlefield are developed and analyzed by each mission area to identify capability issues or deficiencies based on the perceived threats, the envisioned battlefield scenario, the current doctrine, and the size and composition of the forces expected to be available. From these Mission Area Analyses (MAAs) emerge descriptions of requirements which are first considered in the light of possible solution through improved training, changes to the structure of the force, or changes in the way equipment is used to fight the battle. Changes in doctrine and training are the first choices considered since they offer the lowest cost and quickest way to provide the required solution. When it is determined that new or improved equipment is required to address a specific capability issue, TRADOC/AHS turn to the medical materiel developer (USAMRDC) for medical materiel solutions.

TRADOC/AHS guidance to USAMRDC on new materiel requirements is contained in the Battlefield Development Plan (BDP), which integrates and prioritizes the requirements from all MAAs. In some cases this feedback process may provide the solution by using "off-the-shelf" or non-developmental items (NDI). In other cases, a deficiency or capability issue may be resolved by the adoption of equipment from another Service or from an allied country. The capability issues are reviewed by a TRADOC/AHS team to ensure full understanding of the specific need, and also by USAMRDC to provide TRADOC/AHS with feedback on technological options given first consideration, because they eliminate development costs and reduce the time to field the items.

When a requirement can only be satisfied through research and development (R&D) efforts, the medical materiel developer in consonance with the medical combat developer, will plan, program, and budget for Research, Development, Test and Evaluation (RDT&E) Army medical programs. This process includes but is not limited to scheduled events such as the Long Range Research, Development and Acquisition Plan (LRRDAP) Annual/biennial review of advanced development R&D products through the Medical Mission Area Materiel Plan (MedMAMP) provides a process to link the Combat Developer, the materiel developer, and the logistician. MedMAMP prioritization of Army medical RDT&E programs against the BDP ensures the necessary compliance with the CBRS.

Planning Assumptions

The assumptions include those listed in the ALRPG, the MEDMAT, and the following:

- The CBRS will continue to be used to define Army requirements.
- The USAMRDC will continue to discharge responsibilities as the DOD Executive Agent for medical chemical and biological defense.

- The USAMRDC will continue to discharge responsibilities as the Congressional lead agency for infectious diseases of military significance and combat dentistry.

- The USAMRDC will continue to manage and execute the DOD Drug and Vaccine Industrial Base.

- Animal rights activists and anti-biotechnology groups will continue to monitor and inject opposition to Army medical R&D programs, slowing but not halting medical R&D efforts.

- Health service support operations on the battlefield will continue to serve as the combat commander's primary source of trained replacements during the early stages of a conflict.

- FDA regulatory programs will not further impede the medical materiel development and acceptance process in peacetime and will be curtailed in times of national emergency.

Objectives

The objectives are grouped into five major categories: (1) technological superiority; (2) acquisition of critical military informational products and materiel; (3) improvement of the acquisition process; (4) improvement of battlefield casualty management and evacuation; and (5) development of combat stress programs. These objectives, and the strategies to accomplish them are discussed below.

Gain and maintain technological superiority by: encouraging and supporting technological innovation and scientific excellence focusing on biomedical research issues of primary interest to military medical services, utilizing programs such as the In-house Independent Laboratory Research and University Research Initiatives; strengthening and sustaining the DOD vaccine and drug industrial base; and employing broad agency announcements to stimulate and sustain continued interest and participation in Army programs by academic and industrial research organizations.

- Plan, program, and execute Army medical RDA programs to sustain the operational capabilities required to foster and exploit technological advances which provide technology, technological information, and medical materiel required to counter the chemical/biological threats, reduce the historically high incidence of infectious diseases, reduce the impact of military systems health hazards, reduce the effects of combat stress, reduce the effects of environmental extremes, and improve casualty evacuation, treatment, and survivability. Army medical RDA programs will emphasize:

  - Medical biological defense. Explore generic approaches to prevention and treatment which will reduce the burdens on health services and medical logistics, in addition to conserving the fighting forces. Exploit biotechnology to develop prophylaxes, vaccines, drug/vaccine delivery systems, and rapid diagnostic tests for biological warfare (BW) threats, and develop medical materiel to treat BW casualties. Plan, program, and budget to sustain the DOD vaccine and drug industrial base. Toward the year 2009, research efforts will lead to the development of immunological carriers for transport of immunogenic peptides, vectored vaccines which will carry multiple immunogenic properties, the capability to stimulate B or T cells independently or simultaneously, and prophylactic and therapeutic approaches to block the actions of toxins and physiologically active agents on target receptor sites.

  - Medical chemical defense. Focused research efforts on resolving capability issues identified in the CBRS. The development of prophylaxes, pretreatments, antidotes, and skin decontaminants/protectants, including novel delivery systems, effective against known and emerging chemical threats and production of medical materiel required to treat chemical warfare casualties must be maximized. Exploit advances on the neurosciences and biotechnology to reduce incapacitation and/or performance degradation caused by threat

agents or associated medical countermeasures. Plan, program, and budget to sustain the DOD pharmaceutical industrial base. Toward the year 2009, medical chemical countermeasures will provide protection against vesicant and emerging pulmonary threat agents; new generation pretreatments and antidotes will minimize human performance decrements, and generic approaches will be in development to reduce the burdens on health services and logistic support, as well as conserving the fighting strength.

- Infectious diseases of military significance. Exploit biotechnology to develop prophylaxes, vaccines, drug/vaccine delivery systems, diagnostic tests, and treatment materiel against infectious diseases which will reduce the historical impact of infectious diseases on warfighting capability (i.e., 60% to 90% of all hospital admissions in all previous wars and conflicts). Plan, program, and budget to sustain the DOD vaccine and drug industrial base. Toward the year 2009, infectious disease prevention should consider alternative drug delivery systems or vaccines that can be administered on a less than daily or weekly basis, so that continual protection will be provided with minimal or no sustaining treatments required.

- Combat casualty care. Exploit technological breakthroughs to enhance survivability and RTD in order to conserve trained manpower. Develop improved methods and equipment to reduce morbidity and mortality caused by emerging weapon systems (e.g., DE and high fragmentation devices) and potential delays in evacuation of wounded to corps level facilities due to isolation on a high mobility battlefield. Develop next generation diagnostic/treatment methods (e.g., filmless radiography and digital imaging networks) and materiel for shock, trauma, environmental hazards, wounds and burns to enhance the RTD rate. Provide equipment and technology to match the training and capabilities of the health services personnel on the battlefield. Toward the year 2009, combat casualty care technology will utilize synthetic oxygen carrying blood substitutes, artificial skin, degradable tissue/bone replacements, and electromagnetically enhanced wound healing.

- Military systems health hazards. Develop a comprehensive data base on environmental/Army systems health hazards and physiological/psychological limits of human endurance to support the integration and manpower and materiel in Army systems. Recommend control criteria, engineering design, and appropriate strategies to reduce the effects of combat stress, sensory overload, toxic fumes, as well as the effects of environmental hazards such as heat, cold, and altitude. Develop technologies supporting development of materiel to prevent organ damage due to electromagnetic/mechanical forces to include laser, high power microwave, and blast overpressure. Develop products and strategies which reduce the effects of sleep deprivation or inadequate nutrition or hydration. Provide commanders with information products and decision support tools of human performance limitations/decrements and enhancements. This program will provide the materiel and informational products to support dramatic increases in human performance capabilities in the high stress environment of the battlefield.

- Combat dentistry. Exploit technology to rapidly diagnose, treat, and sustain the force against the impact of dental emergencies and combat maxillofacial injuries, thus enhancing the RTD rate. The treatment of most combat maxillofacial injuries will be accomplished within the theater of operations. Surgical procedures will be reduced through the development of new technologies, thus expediting the RTD rate.

Acquisition of critical military informational products and materiel to equip the force with medical materiel and information to resolve user requirements identified in the CBRS.

- Improve reliability, availability, maintainability, and dependability; reduce logistical requirements (e.g., extended shelf-life and generic products addressing multiple threats); and develop and field equipment which is as mobile and survivable as the force it supports.

- Integrate NBC protection; improve electromagnetic pulse (EMP) hardening; facilitate training and maintenance through the use of embedded systems; stress logistic interoperability/commonality between U.S. and allied forces (i.e., Defense Medical Standardization Board, NATO Standardization Agreement, and Quadripartite Standardization Agreement).

- Develop the capability to remove or replace critical technologies to facilitate the transfer of equipment to friendly foreign countries.

Improvement of the acquisition process by incorporating improved business practices throughout the RDA cycle from resource allocation to procurement in fielding the latest technological capabilities.

- Maximize exploitation of currently available technology solutions through use of "off-the-shelf" and modified NDI approach to fielding.

- Align acquisition and fielding procedures for medical materiel/ equipment with Army Total Package Fielding concepts to include provisioning, Associated Support Items of Equipment, Prescribed Load List, POMCUS, and PPWR.

- Optimize use of planned, preconfigured and modular assemblages (i.e., medical sets, kits, and outfits).

Improve battlefield casualty management and evacuation by improving flexibility, mobility, and sustainability of field medical units.

- Develop innovative means of making medical units operational near the source of casualties and improve casualty survivability by acquiring improved evacuation transport. The Medical Force 2000 (MF2K) and DEPMEDS will serve as baseline for future health service systems and materiel development and fielding (e.g., DEPMEDS II).

- Reduce the casualty load through the prevention of endemic infectious disease, preventable injury, NBC, and DE casualties on the integrated battlefield.

- Reduce manpower intensive operations in medical units through mechanization, automation, and or robotics to increase casualty and medical materiel handing efficiency and unit productivity. Reduce paperwork required in medical regulation of casualties and medical logistics through materiel developed to support improved communications, command, control, and intelligence capabilities.

Develop combat stress programs.

- Develop the required physiological/psychological knowledge and medical procedural/materiel countermeasures effective against combat stress brought on by a combat environment that is faster paced, more lethal, and more terrifying than any experienced to date.

- Provide the knowledge and methodology required by commanders to maintain morale and deal with the enduring frustration of tightly drawn rules of engagement, protracted operations against elusive, irregular forces, and related pressures associated with low-intensity conflict.

The long-range planning guidance outlined above relevant to the equipping functional area, is in support of the warfighting capability specified in ALB-F. Accomplishing the objectives discussed above will lead to an Army well equipped with medical materiel, and provided with critical military informational products to prevent casualties from chemical/biological threats, infectious diseases of strategic military significance, military systems health hazards, environmental extremes, and combat stress. This

equipment and technology will also be available to treat combat casualties and return trained manpower to an active fighting status.

OTHER FUNCTIONAL AREAS

Other functional area sections of the HSLRP contain many assumptions, objectives and strategy descriptions relevant to medical R&D program planning. The following excerpts capture selected portions of the guidance contained in those sections.

PLANNING ASSUMPTIONS

Mobilization/Deployment

- There is increasing evidence of development of chemical and biological weapons as primary offensive weapons of mass destruction in Third World countries.
- The demand for lightweight "high-tech" equipment will continue at an unprecedented level to facilitate treatment as far forward as possible and to satisfy the demand for swift intra/inter-theater evacuation of theater casualties.
- The availability of resource acquisition dollars in the future will be lower than or limited to present expenditure levels.
- The out years will be characterized by a reduced industrial/mobilization base.
- With the development of new and more sophisticated weapons systems, the Army will witness an increase in numbers and types of casualties requiring treatment.

Sustainment

- Changes in medical technology will be evolutionary rather than revolutionary in nature.
- Field medical equipment and materiel will mirror industry technology.
- Automated medical electronic instrumentation will significantly change the maintenance methodology of the future. Microprocessor or computer-controlled medical instrumentation will become commonplace and many items will self-test to ensure that gross functions operate correctly. In addition, on-line monitoring functions will continuously check for anomalies in instrument operation.

Medical Treatment

- Most future conflicts will be fought in undeveloped nations, where damage to economic infrastructure will be least. U.S. forces will participate as advisors and occasionally as combatants. Civil assistance programs will be included in U.S. support, and medical assistance will be one of the most popular programs. Reliance on host nation support under these circumstances must be limited.
- Future conflicts are most likely to be of low-or mid-intensity. However, even low-intensity conflict will feature extremely violent combat over extended periods.

- New types of weapons, such as DE or BEW, will pose unprecedented challenges to health service support. Increasingly capable third World military forces will possess potential to proliferate NBC.

- As the number of soldiers decreases, high-risk CSS units will substitute technology for manpower to sustain operations with fewer personnel. MF2K will enjoy limited benefit since it is not now nor is it likely to be possible in the future to substitute technology for direct care providers such as physicians and nurses. Technology will augment the knowledge and increase the skill requirements of health care personnel.

- Nonbattle casualties will continue to comprise up to 90% of all hospital admissions. Preventive medicine advances will offset many personnel losses due to disease compared to those suffered in previous conflicts. Control of tropical diseases, to include parasites, will become more important given the great potential for Third World battlefields in the early 21st Century.

- There will be increased casualties due to environmental extremes and stress, which may offset anticipated reductions in nonbattle casualties due to disease.

- With increasing lethality of weapons, fewer soldiers can be expected to be returned to duty following injury. There will be more killed in action (KIA) and wounded in action (WIA) some will be so severely incapacitated that it will be unrealistic to expect an RTD for large numbers of these soldiers.

- Supply of foodstuffs and water from local sources will be more difficult as environmental hazards and pollutants from warfare are identified.

- Technological advances in medicine will continue to occur rapidly and adapt militarily useful technology, materiel and techniques early in the research, development, and acquisition (RDA) process. Advances will be monitored carefully to identify and adapt early in the product life militarily useful technology, pharmaceuticals, and techniques.

Managing Resources

- Resources available for defense will probably be constrained by concern over the national debt and pressures for social spending driven by the aging U.S. population.

- Spending decisions must be linked to a strategic vision, otherwise there will be heavy pressure to maintain force size and cuts will be taken out of modernization which includes the medical programs.

- Increased battle intensity and duration characterized by the potential introduction of directed energy, nuclear, chemical, and biological munitions will necessitate advanced developments in battlefield medicine and equipment that must be funded and fielded as rapidly as possible.

- The actual and relative numbers of wounded in action versus disease and non-battle injuries will continue to be the primary determinants for medical force structure planning and funding.

- Introduction of complex new equipment will require an increase in the time spent on training and create more demand for resources.

- Reduced industrial capacity in the U.S. will require larger stockpiles of war medical materiel and their pre-positioning in strategic global positions.

OBJECTIVES

Structuring

- Develop a health services force structure that can support more units with the minimum required personnel, medical equipment, and supplies which provide quality care. Expose fewer medics to close combat.

- Design health services force structure units that can provide maximum protection and treatment from enemy chemical, biological, DE and nuclear effects.

- Design medical units as mobile, survivable, and capable of operating in an NBC environment as the forces they support.

Training

- Enhance individual training and unit training by incorporating emerging technology in military medical systems into the training plan.

Mobilization/Deployment

- Increase flexibility to tailor the force to our regional interests, the associated threat, and to operate in a joint/combined environment, with enhanced individual skills on equipment with ever increasing technology.

- Enhance capability to respond, operate, and provide health care support in an NBC environment.

Sustainment

- Automate virtually all CSS operations. Data bases at each level should be integrated to reduce the duplication of data maintained on different systems. Data recorded at the lowest level should be automatically edited, consolidated, and provided to control centers at higher and supporting commands. All data should be interconnected by data links with data bases and systems at higher levels. Data links must be secure, survivable, and reliable.

- Develop medical logistics systems toward a goal of a paperless environment. Systems need to use advanced data technology to reduce or eliminate paper handling requirements.

- Increase workforce productivity through the use of robotic To the extent possible, materiel handling operations after 1999 should feature robotics and semi-autonomous materiel handling equipment to load and unload unit-configured containers according to remote or electronic instructions. Labor or time-intensive tasks should be automated and/or use robotics to the maximum extent possible.

- Develop and field oxygen and other medical gas production equipment down to the combat zone hospital level. This will virtually eliminate the need for transportation and handling of high-volume bottled medical gases.

- Develop and field medical fluid production capability down to the combat zone hospital level. This capability will markedly reduce the recurring lift requirement from the logistics pipeline.

- Develop and field synthetic blood substitutes. This will allow for the use of blood products at the lowest treatment echelon, and ease the logistic burdens associated with supplying and handling frozen or liquid whole blood products.

- Explore other areas of field production of materiel to continue to reduce the logistics tail for the AMEDD and enhance the self-sustainability of AMEDD field units in the combat zone.

- Standardize medical equipment and modules between units and between Services.

- Design component replacement and/or exchange into medical equipment using on-board diagnostic and prognostic capabilities.

- Minimize investment in rapidly available low-risk medical materiel. Procedures for relying on industry to rapidly provide required materiel in a mobilization environment need to be refined and implemented.

- Continue to develop prophylactic/pretreatment materiel for potential high-risk chemical and biological threats. Develop administrative and logistical procedures for rapidly providing developed materiel to the field.

Intelligence

- Ensure medical intelligence which:

  - Provides accurate assessments on the medical effects of conventional weapons systems employed by the enemy. Provide early identification and assessment of potential new/unique threat systems.

  - Provides accurate assessments on the capabilities, limitations, and vulnerabilities of enemy medical materiel, doctrine, and order of battle.

  - Provides accurate and timely assessments on infectious diseases and other health threats occurring within foreign forces and within foreign territory.

  - Provides necessary information on other health hazards within the operational areas which threaten mission accomplishment.

Medical Treatment

- Offset scarce personnel and dollar resources by incorporating resource efficient technologies that are currently available and newly developed.

- Develop mechanisms to counter combat stress, sustain morale, and maintain combat manpower in the face of faster paced, more lethal,and more terrifying conflicts.

- Direct research toward those advances, medical and otherwise, which will be most effective in conservation of personnel resources.

Medical Space

- Medical intelligence. Enhance medical intelligence collection and dissemination through space-based operations and products of space technology.

- Casualty diagnosis. Improve the effectiveness, timeliness, and accuracy of casualty diagnosis, especially in far forward areas, using space technology and space-based operations.

- Casualty treatment. Improve the treatment of battlefield injuries through applications of space technology and develop treatment procedures for injuries and diseases resulting from space-based operations.

- Evacuation and regulating. Improve casualty evacuation and patient regulating procedures through space-based communications and application of space technology.

- Disease and injury prevention. Improve medical capabilities to prevent disease and nonbattle injuries and minimize health hazards on earth and during space operations.

- Biomedical R&D. Exploit space research and developing space technology for medical R&D and manufacture of medical materiel.

STRATEGIES

Structuring

Develop and field a health services support structure that supports the Army's missions and requirements of the Unified and Specified Commands.

- Medical Force 2000 (MF2K) will provide initial and long-range force structure strategy. MF2K tenets emphasize maximum soldier RTDs, soldier health maintenance, standard modular hospital designs, enhanced medical training initiatives, far forward resuscitative care, streamlined organizations within the medical functional areas, and exploitation of high technology. This medical force structure must be able to perform its mission across the entire spectrum of conflict under all climatic conditions.

Develop a health services force structure that can support more units with the minimum required personnel, medical equipment, and supplies to provide quality health care; and expose fewer medics to close combat.

- A strategy to structure health service units that can support more units with less resources must integrate technology, including automation, with evolving health service support doctrine found in MF2K. Force structure designs will produce medical units that can more effectively promote, improve, conserve, or restore soldiers physical or mental well-being. Health services care by its nature is labor intensive, and technology advances will not always save time or manpower. The challenge is to structure a medical force that blends technology with personnel to optimize casualty (including combat stress) management and evacuation to speed return-to-duty. Guidelines for health service doctrine development should consider:

  - Mobile, smaller units with advances resulting from lighter/down-sized equipment exploiting technology.

  - Triage and diagnostic enhancements will effectively sort to evacuate wounded on the battlefield reducing health services structure exposure to sustained, close combat.

  - The capability of medical units is enhanced through improved communication means, "paperless" wartime healthcare documentation, robotics, enhanced air and ground evacuation units, and 2nd generation DEPMEDS equipped hospital units.

  - Advances in technology and a reduced manpower pool are likely to result in more effective medical units, if the planning guidance above is carefully executed. A health

services structure strategy emphasizing units focused on prevention and rapid return-to-duty give combat commanders the primary initial source of replacements.

Design health services force structure units that can provide maximum protection and treatment from enemy chemical, biological, DE and nuclear effects.

- Health services unit structures must be equipped and staffed to survive and treat casualties in chemical, biological, DE, and nuclear battlefield environments. Strategies should exploit advances in vaccines, pretreatments, and antidotes. Increases in battlefield lethality due to DE weapons and combined injuries must be met with medical treatment and evacuation units able to optimize RTD.

Design medical units as mobile survivable, and capable of operating in an NBC environment as the forces they support.

- A strategy to enhance battlefield mobility of health service units on the battlefield uses advances in technology to lighten loads and makes units more self-sustaining. A mobile forward surgical unit will provide an agile and survivable capability throughout the depth of the battlefield. Survivable medical units are structured to perform treatment and evacuation missions in a chemical, biological, or toxin environment.

Manning

Conserve resources through comprehensive preventive medicine and safety efforts.

- Preventive medicine and safety are command responsibilities. The long-range AMEDD strategy must identify hazards and develop programs which support the commander in these areas.

Training

Mission requirements will be the basis for developing unit training.

- The sustainment of basic soldier skills and specialty specific skills will remain crucial to unit readiness. Standardized training programs in an exportable mode will be developed for all components.

- AC/RC commanders must be provided battlefield training simulations which create an environment for commanders and staff to practice the art and science of providing AMEDD support to the warfighters in Army, joint, and combined operations under various integrated battlefield environments. These simulations must be cost-effective, minimize support personnel requirements, and provide the realism necessary to increase the effectiveness of subsequent field training exercises.

Training must be improved to increase effectiveness and conserve training resources through the discriminant use of available technology.

- The incorporation of advancing technology in training structure, i.e., advances in instructional design and curriculum development, and content, i.e., sophistication in task procedures, methods and equipment, must be applied to both individual training and unit training. The AMEDD must carefully analyze training technology initiatives in an effort to save training time and dollars while attempting to raise levels of performance

Mobilization/Deployment

CSS medical units must be properly trained, equipped, and readily deployable to accomplish their wartime mission in support of assigned CINC's objectives.

- Expand participation of small tailored medical support packages in Unified Command's Regional Exercise and Civic Action/Humanitarian Assistance programs.
- Develop and maintain hands-on training programs that emphasize small CSS medical elements capable of operating and self-sustaining in limited NBC environments.
- Continue to develop, field, and sustain and air medical evacuation platform capable of providing tactical and short-range evacuation capabilities.

The procurement and fielding of medical materiel and equipment must be pursued through programs which focus on Tri-service and/or multinational development, standardization, and use.

- Continue the fielding, refinement, and reduction in weight of DEPMEDS equipment.
- Increase emphasis on developmental programs which focus on joint utilization and standardization.

Intelligence

Implement effective measures to obtain feedback and trip reports from Army operational units to further support medical intelligence collection activities.

Enhancing measures required for Armed Forces Medical Intelligence Center (AFMIC) to obtain feedback and trip reports from Army operational units will necessitate:

- Medical intelligence emphasis highlighted during the medical services basic and advanced training courses.
- Applicable Army regulations requiring copies of after-action reports and trip reports to be passed to AFMIC.

Medical Treatment

Technology.

- Increase the effectiveness of ancillary personnel with computer-aided diagnosis and treatment systems for use by especially trained medical aidmen.
- Use technology to free health care providers and ancillary personnel from time-consuming but essential tasks such as medical records maintenance.
- Purchase off-the-shelf, proven technology for field medical units, modifying or hardening for field use as necessary. Cross-train ancillary personnel in maintenance of such equipment in field environment.
- Develop an automated medical records system, eliminating paper to the maximum extent possible, especially for active duty personnel when cost beneficial.

Mobility and communications.

- Ensure that small-unit medical personnel receive more extensive training, and provide more "buddy-aid" or "combat lifesaver" training for the combat soldier.

- Match medical evacuation capabilities to the nature of the units supported, recognizing the lethality of the modern battlefield where vehicles and exposed personnel are concerned. Current ALB-F concepts recognize limitations on mobility, thereby reducing medical evacuation capability and requiring placement of additional medical treatment capability and holding capacity forward.

Medical materiel.

- Actively support R&D efforts for a fast acting non-toxic replacement for ethylene oxide and heat/steam sterilization for those medical items which are nondisposable

Preventive medicine.

- Assure capability to sample and test for environmental and NBC threats from any source must be pushed far forward. Rapid diagnostic testing capabilities in forward areas are necessary to identify disease threats as early as possible, to preserve fighting strength.

- Ensure preventive medicine is an integral part of civil action programs to teach Third World countries how to defend themselves against endemic diseases and parasites, how to properly purify and store water, how to store foods and decontaminate when necessary, and to instill the concept of health promotion.

- Through health promotion programs, raise the level of physical and mental conditioning as a counter to combat stress. Develop stress management teams at installation and major unit level to assist commanders in managing effects of high-stress situations.

- Development and use of vaccines and drugs to prevent against known threats and to enhance soldier effectiveness should be employed.

Dental services.

- The individual soldier must be trained to protect his own dental health by use of a dental sundries pack, to be developed.

- Development and use of materials/technology to reduce dental casualties and ensure more rapid RTD.

Veterinary medicine, occupational and physical therapy, and nutrition care.

- Equipment and techniques for rehabilitation of wounded must be refined to permit deployment as far forward as possible to speed RTD for those soldiers deemed capable.

- Chemical, nuclear or blast effect weapons will create larger numbers of burn casualties, requiring more OT and PT support in convalescent hospitals.

- Nutrition care specialists will provide important support in civil action programs, teaching Third World populations how to store and prepare unfamiliar foodstuffs.

- Warfare in an NBC environment will present special problems in feeding and fluid replacement for soldiers on the battlefield, as well as for patients in the hospital.

- Veterinary interventions will be essential parts of civil action programs to assist indigenous populations in establishing and maintaining animals as sources of both labor and food.

- Veterinary medicine will be important in helping to detect and treat zoonotic disease and preventing spread in humans.

Medical specialty considerations.

- Psychiatry, psychology, and social work will refocus to assist commanders in sustaining their troops through the stress of battle and will, therefore, need to be more forward-deployed.

- NBC conditions will exacerbate the stress due to prolonged wearing of protective equipment and clothing with a resultant sense of isolation on the part of each soldier.

- New techniques or psychotropic drugs or both will be needed to counter this intensified stress during combat with modern weapons and new employment techniques.

Research and development. R&D must proceed with efforts to support strategies outlined. Specific research goals should include:

- Development of dental sundries pack to allow soldiers to maintain dental health when routine dental care is unavailable. This should include antiplaque rinse, toothbrush, floss, and calculus control toothpaste. Distribution can be via rations. Health promotion training should include training in the use of these items.

- Development of materials/technology to replace tissue loss due to avulsive wounds.

- Development of lightweight dental equipment sets with training sets for fixed dental facilities.

- Continued development of genetically engineered vaccines to counter endemic diseases of military significance extant in regions of potential conflict.

- Renewed emphasis on development of personal protective equipment to counter threats from old and new weapons (NBC, DE, or BEW), endemic diseases or parasites when vaccines, drugs, pretreatments, or prophylactic regimens are not available, and from areas contaminated with pollutants from manufacturing or resulting from warfare.

- Continued research of prophylaxis for chemical or biologic agents, and antiradiation treatments.

- Develop equipment that permits evaluation and treatment of casualties in NBC environment without exposing the care provider to unreasonable risk.

- Develop ground evacuation vehicles that can keep up with combat vehicles, allow clearance of the battlefield without undue risk to crews, medical personnel, or the patient, and which provides protection in an NBC environment.

- Pursue development of enhanced and refined air evacuation capability which is suited to the anticipated lethality of the battlefield airspace.

- Continued development of small volume resuscitative intravenous solutions, skin patches to deliver medications topically, blood substitutes, antitoxins to BW agents, microencapsulated antibiotics and other pharmaceuticals for sustained release, dressings impregnated with sustained release antibiotics, implanted drug delivery systems, and malarial vaccines and drugs.

- Continued development of small, hand-held computerized devices to perform multiple diagnostic and record keeping chores in the field and fixed settings.

- Develop robotics to conserve scarce forward-deployed health care provider resources when threatened by exposure to nuclear, BW, or CW agents on the battlefield.

- Continue research into coping mechanisms associated with the stress of various physical environments, to include chemical interventions.

- Continue research into the effects of sleep deprivation and interventions, including chemical, to counter adverse effects such as physical fatigue and lapses in concentration.

- Validate and refine the concept of combat stress relief teams near and within areas of combat.

Managing Resources

Refine management techniques.

- Managing in the long range must take into account continued threats to the nation's security and their impact on the Army's health services. Management techniques must be continually refined to reflect changes in military technology developed to cope with perceived threats. In the medical arena this means medical programs must be expanded to keep pace with military technology. The need for educating AMEDD managers will grow with the development of complex systems.

- Ensure that AMEDD managers pursue skills training for performing proficiently and with appropriate techniques. The AMEDD must nurture an environment in which its managers can develop a creative sense of discovering new and unique ideas, readily perceive pertinent factors, easily visualize key problems, and confidently apply best solutions.

- The AMEDD must continue to send its managers to the best schools that support Army management philosophy and doctrine. AMEDD managers will need a stronger foundation in science, mathematics, and reading skills. The quality of their education will be a key factor in shaping the AMEDD's ability to adapt to world changes affecting national security.

Streamline administration by reducing paper transactions.

- Computers will continue to present opportunities for improvement, especially in the areas of report management and program management. AMEDD managers must be able to gain access to all types of computer networks linking them with data banks and other medical health professionals working on military health services issues. Increases in computer networking will reduce paper transactions by allowing machine to machine communications where voice, data, and texts are exchanged automatically between computers. AMEDD resource managers will continue to promote office automation for improving information exchange and retrieval.

Provide commanders the best affordable management tools

- AMEDD managers, while having access to computerized data banks and problem solving rules, will also need to critically evaluate, communicate and apply the information they receive as it

relates to their particular area of responsibility. They will need to know the Federal budgeting process and use it to the AMEDD's full advantage in order to determine requirements to organize, equip, and train approved medical force units; to sustain their operations; and to convert the requirements into dollars and manpower to meet AMEDD goals as outlined in the ALRPG.

Annex D

JOINT SERVICE AGREEMENT MEDICAL REQUIREMENTS

SCIENCE NEEDS

1. Prophylactic Drugs

Identification Number. S-A-301 (USN, USAF)*

Description. Develop prophylactic drugs without debilitating side effects which prevent or ameliorate the effects of those CW agents most likely to be encountered on the integrated battlefield.

2. Antidotes

Identification Number. S-A-302 (USAF, USN)

Description. Develop CW agent antidotes which preserve both soldier life and soldier effectiveness.

3. CW and BW Therapeutic Drugs

Identification Number. S-A-303 (USAF, USN)

Description. Develop therapeutic drugs to treat CW and BW agent casualties in the post-exposure phase of chemical and biological casualty management.

4. System for Treatment, Evacuation, Management of Casualties

Identification Number. S-A-304 (USAF, USN)

Description. Develop an effective system for medical treatment, evacuation, and management for CW and/or combined CW traumatic casualties.

5. Patient Decontamination

Identification Number. S-A-305 (USAF, USN)

Description. Develop new and effective means of patient decontamination for the CW casualty, the conventional casualty, and the combined CW and conventional casualty. This includes determining the absorption rates and effects of absorption of CW agents (vapor and liquid) through wounds and the optimal methods for decontamination of wounds.

6. Life Support Materiel

Identification Number. S-A-306 (USAF)

Description. Development of medical CW defense life support material (e.g., resuscitators) using normal development means and exploitation of foreign medical materiel

* Indicates Service(s) interest

7. Means to Assess Casualties

Identification Number. S-A-307 (USN, USAF)

Description. Develop means to assess CW agent casualties and to monitor patients for presence of contamination and determination of when the decontamination process has rendered casualties safe for entry into a treatment/patient area.

8. Means of Soldier Self Assessment

Identification Number. S-A-308 (USAF)

Description. Develop means of self-assessment and early treatment for use by the individual soldier.

9. Training Devices for Prophylaxes/Antidotes

Identification Number. S-A-309 (USAF)

Description. Provide necessary input for development of training devices to instruct in the use of CW prophylaxes/antidotes.

10. Effects of Combined Medications/Anesthesia

Identification Number. S-A-310 (USAF, USN)

Description. Determine the effects of CW agent prophylaxes, pretreatment compounds, antidotes, and therapeutic compounds upon: (a) the effectiveness of other medication being simultaneously or sequentially administered to patients with other wounds, injuries, or illnesses; (b) the effectiveness of all forms of anesthesia when administered simultaneously (or in tandem) with the various anti-CW agent medications.

11. Return-to-Duty Criteria

Identification Number. S-A-311 (USAF)

Description. Develop rational return-to-duty criteria for the CW agent casualty who has survived and has been convalescing.

12. Medical Contraindications

Identification Number. S-A-312 (USAF)

Description. Determine otherwise harmless medications that are significantly contraindicated for the patient who has anti-CW agent medications currently in his system.

13. Side Effects of CW Medications

Identification Number. S-A-313 (USAF)

Description. Determine the characteristic side effects of pretreatment compounds, prophylaxes, antidotes, and therapeutic compounds administered in both the absence and presence of a CW agent

challenge, the degree and nature of side effects, the nature of the military task performance degradations, and the duration of the ineffective state of a variety of critical military positions.

14. Agent Effects on Conventional Wounds

Identification Number. S-A-314 (USAF)

Description. Determine the effects of CW agents on conventional wound healing; radiation on CW agent injury; radiation on infections; CW agents on infections; radiation and CW agents on the overall immunity status.

15. Prophylaxis for Biological Agent Exposure

Identification Number. S-A-315 (USAF)

Description. Develop prophylactic measures (drugs, vaccines, rapid identification) to protect soldiers from the effects of deliberately employed biological disease agents.

16. Therapy for Biological Agent Exposure

Identification Number. S-A-316 (USAF)

Description. Develop therapeutic measures (antidotes, therapeutic agents and rapid identification) to protect soldiers from the effects of deliberately employed biological disease agents. Treat BW agent casualties in the post exposure phase of biological casualty management.

17. Chemical Agent Dosimeter

Identification Number. S-A-317 (USAF)

Description. A chemical agent dosimeter is required to measure the accumulated low dose exposure levels that medical personnel may acquire while treating chemical patients in a collective protection system. This dosimeter will inform medical personnel if they are approaching a symptomatic dose level, so appropriate actions can be taken.

18. Advanced Life Detector

Identification Number. S-A-318 (USN)

Description. Develop technology and specifications for an expert system driven patient ventilator system. While the system is sophisticated technically, it is required to be a portable, one-per-patient type system, under 10 kg in weight (excluding gas supply). This system would be used for the ventilation of mass casualties that require ventilatory support because of exposure to chemical agents. The prototype also will work at altitude and during decompression.

CHEMICAL DATA NEEDS

1 Exposure Symptoms

Identification Number. C-A-301 (USAF, USN, USMC)

Chemical Data Need. Determine the battlefield symptoms and the time of response (onset of physiological effect) of individuals exposed to liquid and/or vapor of chemical-biological agents.

2. Biotechnology

Identification Number. C-A-302 (USAF)

Chemical Data Need. Determine the mechanisms of action of existing and potential threat CW agents and mixtures of agents, and the mechanisms of action of existing and potential pretreatment, prophylaxis and treatment compounds. Explore emerging biotechnology for medical CW defense applications.

3 Pretreatment Models

Identification Number. C-A-303 (USAF)

Chemical Data Need. Establish a system of nonanimal and living animal models to evaluate potential new pretreatment, prophylaxis and treatment compounds against identified CW agents, such that the effect and safety of the potential treatment substance can be accurately estimated for single or multiple doses or for various combinations of drugs.

4 Skin Protection

Identification Number. C-A-304 (USAF)

Chemical Data Need. Determine skin toxicity and skin penetration characteristics of CW threat agents and establish a model system to estimate the degree of skin protection and the effects of decontaminants in support of the soldier patient decontamination and protection program.

5 Physical/Mental Effects

Identification Number. C-A-305 (USAF)

Chemical Data Need. Determine the sequence and severity of the physical and mental effects on man of CW agents so that effective field treatment techniques are available for individuals exposed to threat CW agents. Of special interest are the effects upon pilots and other vision sensitive skills. Describe the severity of effects of chemical biological agent or toxin induced injuries as a function of agent, dosage level, dosage rate, and medical treatment.

6 Soldier Response to Agents

Identification Number. C-A-306 (USAF)

Chemical Data Need. Using animal studies, determine soldier response to battlefield agents, agent mixtures, and derivative products by routes (single and multiple) of entry. Validate the responses as a function of MOPP level by performance decrement for representative military tasks.

7. Physiological Response Effects

Identification Number. C-A-307 (USAF)

Chemical Data Need. Develop physical assessment methods and techniques to replace animal/biological models in determining physiological response effects.

8. Chemical Casualties

Identification Number. C-A-308 (USAF)

Chemical Data Need. Describe the type of casualties expected to be seen on a chemical battlefield by organ, site, and system of involvement.

9. Effects of Exposure

Identification Number. C-A-309 (USAF)

Chemical Data Need. Describe the temporary and permanent effects from exposure to chemical agents of mixtures.

10. Effects of Repeated Low Level Exposures

Identification Number. C-A-310 (USAF)

Chemical Data Need. Identify the acute effects of repeated exposure to low levels of chemical agents/mixtures by various routes of entry. Compare these effects to similar effects produced by a single exposure to a high concentration of the agent/mixture.

11. Animal Model Simulation

Identification Number. C-A-311 (USAF)

Chemical Data Need. Identify appropriate animal models to correlate human responses to chemical agents/mixtures. Animal models will include a program to evaluate/inform researchers of appropriate handling and care procedures within Federal guidelines.

12. Psychological Effects

Identification Number. C-A-312

Chemical Data Need. Investigate the psychological stress from prolonged wear of chemical protective gear (MOPP).

13. Combined Agent Effects Models

Identification Number. C-A-313 (USAF)

Chemical Data Need. Develop an animal model to evaluate the combined effects of a sequence of weapons that includes conventional, nuclear, chemical, and biological (toxins and pathogens) weapons. Correlate these effects with human responses and determine specific medical criteria that will provide an

effective means of evaluating the amount of risk to personnel. Develop the data for realistic scenarios/ sequences of employment.

14. Patient Mortality/Morbidity

Identification Number. C-A-314 (USAF)

Chemical Data Need. Estimate patient mortality and morbidity of personnel that have been exposed to a combination of conventional, nuclear, chemical, and biological weapons, and determine the effectiveness of diagnostic and therapeutic techniques to counter these effects.

15. Duration of Injuries

Identification Number. C-A-315 (USAF)

Chemical Data Need. Determine the extent or duration of chemical agent and threat toxin induced injuries as functions of agent, dosage, dose rate, and medical treatment.

16. Casualty Treatment

Identification Number. C-A-316 (USAF)

Chemical Data Need. Identify required medical treatment for chemical and biological casualties and the latent effects of battlefield agents on personnel at various times after exposure.

17. MOPP Risks Before and After Decontamination

Identification Number. C-A-317 (USAF)

Chemical Data Need. Determine the probability of receiving casualties as a function of level of protection (MOPP level), during and after decontamination procedures for typical military scenarios and emergencies.

18. Unit Degradation-Medical Units

Identification Number. C-A-318 (USAF)

Chemical Data Need. Quantify the degradation of medical units and facilities (from aid stations to field hospitals) to perform their normal missions in a chemically contaminated environment.

19. Antidote Induced Noneffectiveness

Identification Number. C-A-319 (USAF)

Chemical Data Need. Evaluate the medical and operational implications of antidote-induced noneffectiveness related to the current self-treatment regimens.

20. Biomedical Implications

Identification Number C-A-320 (USAF)

Chemical Data Need. Determine the biomedical implications of current threat agents and employment concepts, e.g., combinations of conventional and chemical weapons. Include both single and multiple agent delivery. Determine performance degradation at various levels of agent exposure (threshold to incapacitation) to include miosis-induced noneffectiveness).

21. Safe Food Sources in CW Environment

Identification Number. C-A-321 (USAF)

Chemical Data Need. Determine sources of food that can be compatible with protective equipment, that remain safe in a chemical warfare environment and provide safety nutrition needs of personnel in protective ensemble.

22. Medical Effects of Conventional Biological Warfare Agents

Identification Number. C-A-322 (USAF)

Chemical Data Need. Assess in animal models of human disease the mechanism of action, target organ and physiological response to conventional agents that pose a BW threat to provide a data base or medical defensive measures.

23. Animal Model to Establish Data for Water Contaminated by CW Agents

Identification Number. C-A-323

Chemical Data Need. Animal test models need to be established to develop data bases for target human performance requirements based upon oral consumption of chemical agents from water. Short and long term consumption periods need to be addressed based on the combat effectiveness requirements of most sensitive MOS's.

24. Medical Effects of Toxins of Biological Origin

Identification Number. C-A-324 (USAF)

Chemical Data Need. Assess in animal models of human disease the mechanism of action, target organ and physiological response to toxins of biological origin that pose a Biological Warfare (BW) threat in order to provide a data base of medical defensive measures. This includes determining the absorption rates and effects of absorption of BW agents through wounds and the optimal methods for decontamination of wounds.

25. Medical Effects of Physiologically Active Compounds (PACs)

Identification Number. C-A-325

Chemical Data Need. To assess medical effects of physiologically active compounds under various routes of administration (aerosol, oral, percutaneous).

Annex E

GLOSSARY OF ACRONYMS

AAE	Army Acquisition Executive
ABCA	America, Britain, Canada, Australia
AEHA	Army Environmental Hygiene Agency
AFRRI	Armed Forces Radiobiology Research Institute
AHS	Academy of Health Sciences
AI	Artificial Intelligence
AIDS	Acquired Immune Deficiency Syndrome
ALB	AirLand Battle
ALB-F	AirLand Battle-Future
ALRPG	Army Long Range Planning Guidance
ALRPS	Army Long Range Planning System
AMA	American Medical Association
AMADP	Army Materiel Acquisition Decision Process
AMC	Army Materiel Command
AMEDD	Army Medical Department
AMLO	Acquisition Management Liaison Office
AMM	Army Modernization Memorandum
ARD	Acute Respiratory Disease
ARI	Army Research Institute
ARTEP	Army Training and Evaluation Program
ASA	Assistant Secretary of the Army
ASBREM	Armed Services Biomedical Research Evaluation and Management (Committee)
ASD(HA)	Assistant Secretary of Defense for Health Affairs
ASGRD	Assistant Surgeon General for Research and Development
ATBMP	Army Technology Base Master Plan
ATSD(AE)	Assistant to the Secretary of Defense, Atomic Energy
ATTD	Advanced Technology Transition Demonstration
AURA	Army Unit Resiliency Analysis
AZT	Azidothymidine
BDP	Battlefield Development Plan
BDRP	Biological Defense Research Program
BEW	Blast Effect Weapons
BFMA	Battlefield Functional Mission Area
BLPS	Ballistic-Laser Protective Spectacles
BTI	Balanced Technology Initiative
BW	Biological Warfare
C4	Command, Control, Communications, and Computers
CAC	Combined Arms Center
CACDA	Combined Arms Combat Developments Activity
CAPMI	Computer Assisted Post Mortem Identification
CAPSTONE	(Generic term for all inclusive-type documents)
CASTFOREM	Combined Arms and Support Task Force Evaluation Model
CB	Chemical Biological
CBD	Chemical Biological Defense

CBRS	Concept-Based Requirements System
CBTDEV	Combat Developers
CDC	Center for Disease Control
CDN	Chemical Data Need (JSA)
CG	Commanding General
cGMP	Current Good Manufacturing Practice
CINC	Commander in Chief
CIs	Capability Issues
CNS	Central Nervous System
CNVEO	Center for Night Vision and Electro-Optics
COMMZ	Communication Zone
CONUS	Continental United States
COR	Contracting Officer's Representative
CORDIVEM	Corps/Division Evaluation Model
CP	Capability Package
CRDA	Cooperative Research and Development Agreement
CSA	Chief of Staff, Army
CSS	Combat Service Support
CW	Chemical Warfare
CWA	Chemical Warfare Agent(s)
DA	Department of the Army
DARPA	Defense Advanced Research Projects Agency
DATEC	Drug Assessment Technical Evaluation Committee
DATSD(CM)	Deputy Assistant to the Secretary of Defense, Chemical Matters
DCO	Deputy Commanding Officer
DCS	Deputy Chief of Staff
DCSCD (TRADOC)	Deputy Chief of Staff for Combat Development (Training and Doctrine Command)
DCSLOG	Deputy Chief of Staff for Logistics
DCSOPS	Deputy Chief of Staff for Operations [U.S. Army]
DCSPER	Deputy Chief of Staff for Personnel
DCSRDA	Deputy Chief of Staff for Research, Development, and Acquisition
DDDRE(R&AT)	Deputy Director of Defense Research and Engineering, Research and Advanced Technology
DDRE	Director of Defense for Research and Engineering
DE	Directed Energy
DEA	Data Exchange Agreement
DEPMEDS	Deployable Medical Systems
DISC-4	Director of Information Systems for C4
DLA	Defense Logistics Agency
DN	Decision Network
DNA	Deoxyribonucleic Acid
DNBI	Disease Nonbattle Injury
DoD	Department of Defense
DPSC	Defense Personnel Support Center
DSB	Defense Science Board
DTIC	Defense Technical Information Center
DTLOM	Doctrine, Training, Leader Development, Organization and Materiel
EIS	Environmental Impact Statement
ELISA	Enzyme-linked Immuno-absorbent Assay
E&LS	Environmental and Life Sciences

EME	Electromagnetic Energy
EO	Executive Order
EPA	U.S. Environmental Protection Agency
FDA	[U.S.] Food and Drug Administration
FLOT	Forward Line of Troops
FLRRDAP	Field Long Range Research Development Acquisition Plan
FM	Financial Management
FOA	Field Operating Agency
FORCEM	Force Evaluation Model
FORSCOM	Forces Command
FSD	Full-Scale Development
FY	Fiscal Year
GAO	General Accounting Office
GCP	Good Clinical Practice
GLP	Good Laboratory Practice
GMP	Good Manufacturing Practices
HCA	Head of Contracting Activity
HFRS	Hemorrhagic Fever with Renal Syndrome
HHA	Health Hazard Assessment
HHS	Department of Health and Human Services
HIV	Human Immunodeficiency Virus
HQDA	Headquarters, Department of the Army
HSC	Health Services Command
HSLRP	Health Services Long-Range Plan
IL&E	Installation, Logistics, and Environment
IDE	Investigational Device Exemptions
IMO	Information Management Office
IND	Investigation Exemption for a New Drug
IPA	Intra-governmental Personnel Act
IRHA	Injured as a Result of Hostile Action
IWFORCEM	Integrated Warfare Force Evaluation Model
JCS	Joint Chiefs of Staff
JCS/CSA	Joint Chiefs of Staff/Chief of Staff, Army
JMSNS	Justification for Major Systems New Start
JSA	Joint Service Agreement
JSRG	Joint Service Review Group
JTCG	Joint Technology Coordinating Group
KIA	Killed In Action
LAIR	Letterman Army Institute of Research
LCSMM	Life Cycle System Management Model
LD	Limited Duty
LOGCEN	Logistics Center, Ft Lee
LRRDAP	Long-Range Research, Development, and Acquisition Plan
M&RA	Manpower and Reserve Affairs
MAA	Mission Area Analysis

MADP	Mission Area Development Plan
MAMP	Mission Area Materiel Plan
MANPRINT	Manpower and Personnel Integration
MAR	Materiel Acquisition Requirement (JSA)
MATDEV	Materiel Developer(s)
MCA	Military Construction, Army
MDEP	Management Decision Package
MedMAMP	Medical Mission Area Materiel Plan
MedMAT	Medical Mission Area Threat
MEPS	Military Entrance Processing Station
MEPSCAT	Military Entrance Physical Strength Capacity Test
MF2K	Medical Force 2000
MIPR	Military Interagency Purchase Request
MOA	Memorandum of Agreement
MOPP	Mission-Oriented Protective Posture
MOS	Military Occupational Specialty
MOU	Memorandum of Understanding
MRI	Magnetic Resonance Imaging
MS	Milestone (0, I, II, III)
MSC	Major Subordinate Command
MSRC	Medical Systems Review Committee
MTBMP	Medical Technology Base Master Plan
MW	Microwave
MWD	Military Working Dogs
MWDDEA	Mutual Weapons Development Data Exchange Agreement
NAS	National Academy of Sciences
NATO	North Atlantic Treaty Organization
NBC	Nuclear, Biological, Chemical
NDA	New Drug Application
NDI	Nondevelopmental Item(s)
NEPA	National Environmental Policy Act
NIH	National Institutes of Health
NSF	National Science Foundation
O&O	Operational and Organizational Plan
OASA	Office of the Assistant Secretary of the Army
OCONUS	Outside the Continental United States
ODCSOPS	Office of the Deputy Chief of Staff for Operations and Plans
ODDDRE (R&AT)	Office of the Deputy Director of Defense for Research and Engineering, Research and Advanced Technology
OMA	Operations and Maintenance, Army
OPM	"Other People's Money"
OR	Operations Research
ORDA	NIH Office of Recombinant DNA Activities
OSD	Office of the Secretary of Defense
OSH	DoD Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
OSHAct	Occupational Safety and Health Act
OTSG	Office of The Surgeon General
OTSG HCL	Office of The Surgeon General - Health Care Logistics Directorate
OUSD(A)	Office of the Under Secretary of Defense (Acquisition)

PA&E	Program Analysis and Evaluation
PACs	Physiologically Active Compounds
PAHO	Pan American Health Organization
PARC	Principal Assistant Responsible for Contracting
PBAC	Program Budget Advisory Committee
PBC	Program Budget Committee (2-Star Review)
PHS	Public Health Service
PM	Program Manager
PMA	Pre-Market Approval
POM	Program Objective Memorandum
POMCUS	Pre-Positioned Overseas Materiel Configured to Unit Sets
PPB	Plans, Programs and Budgeting
PPBES	Planning, Programming, Budgeting, and Execution System
PPWR	Pre-Positioned War Reserves
QWG	Quadripartite Working Group
QWGHSS	Quadripartite Working Group Health Service Support
R&D	Research and Development
R&LM	Research and Laboratory Management
RA	Research Area
RAC	NIH Recombinant Advisory Committee
RAD	Research Area Director(ates)
RAM	Reliability, Availability, and Maintainability
RDA	Research, Development, and Acquisition
RDT&E	Research, Development, Test, and Evaluation
RF	Radio Frequency
RISTA	Reconnaissance, Intelligence, Surveillance, and Target Acquisition
ROC	Required Operational Capability
RPMA	Real Property Maintenance Activity
RSG3	Research Study Group 3 (NATO Panel)
RSG8	Research Study Group 8 (NATO Panel)
RTD	Return to Duty
S&T	Science and Technology
SCORES EUROPE V	Scenario Oriented Recurring Evaluation System, Europe V
SELCOM	Select Committee (3-Star Review)
SIPE	Soldier-Integrated Protective Ensemble
SME	Subject Matter Experts
SOF	Special Operations Forces
SOP	Standard Operating Procedure
SORD	Soldier-Oriented Research and Development
SOS	Systems of Systems
STD	Sexually Transmitted Diseases
STO	Science and Technology Objective
STOG	Special Technical Operations Group
TAM	Task or Technical Area Manager
TBIS	Technology Base Investment Strategy
TDA	Table of Distributions and Allowances
TECH DEMOS	Technology Demonstrations
TOA	Total Obligation Authority
TRADOC	Training and Doctrine Command

TSG	The Surgeon General [U.S. Army]
TSO	Technology Staff Officer(s)
TT-1	Technical Test-1
TT-2	Technical Test-2
TTCP	The Technical Cooperation Program
USAARL	U.S. Army Aeromedical Research Laboratory
USABRDL	U.S. Army Biomedical Research and Development Laboratory
USAF	United States Air Force
USAIDR	U.S. Army Institute of Dental Research
USAISR	U.S. Army Institute of Surgical Research
USAMMA	U.S. Army Medical Materiel Agency
USAMMDA	U.S. Army Medical Materiel Development Activity
USAMRAA	U.S. Army Medical Research Acquisition Activity
USAMRDC	U.S. Army Medical Research and Development Command
USAMRICD	U.S. Army Medical Research Institute of Chemical Defense
USAMRIID	U.S. Army Medical Research Institute of Infectious Diseases
USARIEM	U.S. Army Research Institute of Environmental Medicine
USD(A)	Under Secretary of Defense (Acquisition)
USDA	U.S. Department of Agriculture
USN	United States Navy
USUHS	Uniformed Services University of Health Sciences
VA	Veterans Administration
VEE	Venezuelan Equine Encephalomyelitis
WBS	Work Breakdown Structure
WHO	World Health Organization
WIA	Wounded In Action
WG	War Gases
WRAIR	Walter Reed Army Institute of Research
WRAMC	Walter Reed Army Medical Center
WWI	World War I
WWII	World War II