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

ARMY SCIENCE BOARD

1991 SUMMER STUDY

FINAL REPORT

SOLDIER AS A SYSTEM

DECEMBER 1991

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In his 29 January 1991 tasking letter, Mr. Stephen K. Conver, Assistant Secretary of the Army (Research, Development and Acquisition), requested Dr. Duane A. Adams, Chairman of the Army Science Board (ASB) to appoint a panel of members to conduct a 1991 Summer Study of the Soldier as a System. The letter stated that "The purpose of this study is to explore in greater depth the logical evolution and implications of pursuing an integrated approach to development, fielding, and management of soldier related material."

The twelve member panel met in full session approximately once a month from February through June 1991. The Infantry School at Fort Benning, three Army Materiel Command organizations, and the Medical Research and Development Command were hosts of these meetings. The Panel narrowed its charter to six issues at the core of the Soldier System concept:

- Integration: the Soldier System must fuse an integrated perspective with a modular approach to the development and acquisition of soldier items to assure maximum synergy and optimal soldier performance.
- Requirements: requirements which soldier performance and materiel must meet should be derived from the future battlefield threat. This requirements assessment for the soldier has not been performed in the context of the Concept-Based Requirements System (CBRS).

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- Acquisition: In the absence of formal requirements (see above issue), the acquisition process tends to be driven by available technologies.
- Architecture: soldier materiel items must be structured into an integrated architecture to permit item/performance tradeoffs.
- Technology Assessment: existing and foreseeable technologies offer opportunities for soldier performance enhancement, but limited resources will mandate careful selection based on value and true availability.
- Soldier Integrated Protective Ensemble Advanced Technology Transition Demonstration (SIPE ATTD): the success of this first attempt at assessment of the performance of specific soldier materiel in an architecture is key to the Army's continued emphasis on the soldier as a system.

The ASB Panel concluded that soldiers are not managed as a system; they need to be; and they need a single focal point in key places. The Panel's principal recommendations are that:

- The Chief of Staff of the Army should approve the Soldier Modernization Plan through Block I.
- The Army Acquisition Executive should appoint a General Officer to manage the Soldier System.
- The Assistant Secretary of the Army (Research, Development and Acquisition) should establish a focal point in his headquarters organization to manage the Soldier System technology base program for the total Army.
- The Deputy Chief of Staff for Intelligence needs to develop a scenario-based threat for the future Soldier System.
- The Commanding General, Army Training and Doctrine Command should complete the CBRS analyses through the Soldier System level.

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EXECUTIVE SUMMARY

Among the senior Army Leadership there has always been recognition that the soldier is the single most important asset the Army has. It is the soldier with his intelligence, flexibility and adaptability who ultimately accomplishes Army missions and functions. Furthermore, it is the soldier who must operate the simple and complex equipment and weapon systems the Army uses. In the future, Army equipment and weapon systems will become even more sophisticated and complex so the soldier's intelligence, training, flexibility and adaptability will become increasingly important.

The terms of reference said: evaluate all aspects of the "Soldier as a System"; consider how we do business today and whether that should change for the future; identify potential soldier performance "leap-aheads" and enabling technologies; consider psychological and physiological interfaces and assess science and technology: "Is it good enough?"

We looked at the processes. We considered the changing nature of the threat and current technologies and development programs. We concluded that one must consider the soldier "skin in" as well as "skin out," as we assess the cost/benefit of the soldier performance leap ahead technologies. Generally speaking, we have the science and technology; the need is to get science and technology resources focused on Soldier System performance. Limitations of time and resources restricted the level of detail and scope that could be explored and focused the ASB on the dismounted soldier as a representative example of all soldiers. We analyzed the terms of reference and we summarized our task as: **"moving the soldier of today to the enhanced capabilities of the future."**

The Soldier System is in transition and still developing. As currently defined, the "Soldier System" consists of the individual soldier and items and equipment which the individual soldier wears, carries or consumes for his or her personal use. In July 1991, the Chief of Staff of the Army enlarged the definition to all that supports the living and working conditions of soldiers in the field. However, the Soldier System definition explicitly excludes materiel required for unit mission purposes, equipment which may be part of the soldier's load but not materiel for his or her individual use, e.g., crew served weapons/munitions, unit radio.

All the multiple components of the Soldier System – the programs, organization, systems, technologies, and soldier types – interact and interrelate. The justification for treating the Soldier System as a major system with integrated management perspective, although potent, must not overlook the difficulties of such an approach. The Soldier System Manager must manage complexity of a high order. Multiple layers of organizations and players affect the requirements definition process and the related development and acquisition of Soldier System equipment and clothing. Also, the Soldier System must explicitly respect the fact that not all Soldier System items worn or used by soldiers are necessary to perform each soldier function, and, therefore, the collective impact that the weight of such items have on the soldier's functional effectiveness must be incorporated into the analytic perspective.

While acknowledging that achieving an integrated system management perspective for the Soldier System will not be easy, this Army Science Board Summer Study Panel believes it is a necessary precondition for facilitating the transition from the Soldiers of Today – with all their present capabilities -- to the Soldier of Tomorrow – with future soldier capabilities embedded in new missions, roles and functions.

To assist in this transition process, new approaches must provide an integrated focus for tradeoffs and capability analyses between soldier, soldier systems and soldier materiel to realize and develop the power of the future soldier. The desired "system" approach must consider the Soldier System items – materiel and non-materiel – and evaluate the research, development and acquisition of these items in light of three critical relationships and related tradeoff analyses: (1) the functional interaction between soldiers and their clothing and individual equipment; (2) the functional interaction of the equipment components, which must operate alone or together; and (3) the interaction between soldier-performance, equipment weight and total soldier-carried load. The need for this perspective – both integrated and modular – provides the justification for and a framework around which the Soldier System must be built. Six issues emerged at the core of the Soldier System concept. They are:

Requirements:

- The requirements which soldier performance and materiel must meet should be derived from the functions soldiers must perform in the face of the threat on the future battlefield. The Concept-Based Requirements System has not been completed and we recommend that it be accomplished in order to guide materiel procurement and training for the future Soldier System.

Acquisition:

- At present, in the absence of formally derived needs and requirements, the research, development and acquisition process tends to be driven by the available technologies. As soon as possible we recommend that the Soldier Modernization Plan for the Block I soldier be approved and incorporated in the next revision of the Tech Base Master Plan.

Integration:

- To assure maximum synergy and optimal soldier performance, the Soldier System must fuse an integrated perspective with a modular approach to the development and acquisition of soldier items. We recommend the appointment of a General Officer Manager for the development and acquisition of soldier system items.

Architecture:

- Since soldier materiel items interact both in function and in their contribution to the total weight carried by the soldier, it is necessary that these materiel items be structured into an integrated architecture to make these interactions explicit and reveal the item/performance tradeoff considerations. However, the systems architecture also must encompass a modular concept since not all items will be required for every task, and performance advantages may be gained by allowing flexible deletion from the soldier's load of those items not required for the specific task at hand. We recommend approval of the integrated and modular architecture.

Technology Assessment:

- Numerous potential opportunities for soldier performance enhancement are presented by existing and foreseeable technology. Not all these are equally likely to be successful nor do they all have equal potential value. Therefore, in the face of limited resources we recommend an assessment of the likely value and likely availability of the various possibilities and consider possible alternatives in order to maximize the use of available resources. See Appendices E and F.

SIPE ATTD:

The Soldier Integrated Protective Ensemble Advanced Technology Transition Demonstration (SIPE ATTD) is important in two ways:

- First, it experiments with setting performance assessment goals above the component level, thus requiring cooperation and coordination among numbers of developers and providers of differing components. Second, it involves an assessment of the performance capability of a specific assemblage of components in an architecture called the SIPE. We recommend that the specific test design and exit criteria be defined in detail.

IN SUMMARY, THE ASB KEY RECOMMENDATIONS ARE:

- Chief of Staff of the Army approve the Soldier Modernization Plan through Block I;
- Army Acquisition Executive appoint a General Officer Manager to integrate and manage the Soldier System;
- Assistant Secretary of the Army (RDA) establish a focal point in SARDA to manage the Soldier System Tech Base Program for the total Army;
- Deputy Chief of Staff for Intelligence develop a scenario-based threat for the future Soldier System;
- Commanding General, TRADOC complete the CBRS analyses through the Soldier System level with the attendant list of prioritized capability needs.

Soldiers are not managed as a system. They need to be. The Army needs a single focal point for the soldier in key places. TRADOC has one in the TRADOC System Manager. We need others.

We believe that approval of the Soldier Modernization Plan through Block I is important and will send a message to the rest of the Army approving the concept of the "Soldier as a System."

Our war fighting edge is the soldier.
We must equip the soldier with the best.
Integrated, focused Soldier System management
provides that opportunity.

The task ahead of all of us, "The Soldier as a System," as outlined in this report, is never as great as the power behind us. **We urge the leadership in the Army to provide that power.**

The Soldier is the Keystone

"Our warfighting edge is the combined effect of quality people, trained to razor sharpness, outfitted with modern equipment, led by tough, competent leaders, structured into an appropriate mix of forces by type, and employed according to up-to-date doctrine . . . ***I am certain the single most important factor is the soldier."***

General Sullivan
July 1991

Among the Senior Army Leadership, there is increasing recognition that the soldier is the single most important asset the Army has. This is exemplified by General Sullivan's comments, quoted above, which introduce and set the tone for this study.

It is the soldier with his intelligence, flexibility and adaptability which ultimately accomplishes Army missions and functions. Furthermore, it is the soldier who must operate the simple and the complex equipment and weapon systems the Army uses.

In the future, Army equipment and weapon systems will become even more sophisticated and complex so the soldier's intelligence, training, flexibility and adaptability will become increasingly important.

General Sullivan is not the first person to say words like this about the importance of the soldier. However, actions have not always followed words. The purpose of this report is to remind the leadership of the Army that it is now time for some actions at their level to be implemented and why.

Briefing Outline

- Introduction
- Overview
- Issues, Findings and Recommendations

The report consists of an introduction, an overview of the Soldier System and six issues with findings and recommendations.

The introduction includes the terms of reference, the list of participants and a discussion of our information sources.

The overview explains the Soldier System definition, the complexity challenge and a conclusion.

The six issues addressed concern the requirement process and the research, development and acquisition process, as well as issues dealing with integration, architecture, technology assessment and the Soldier Integrated Protective Ensemble (SIPE) .

Terms of Reference

- **Evaluate all aspects of the "Soldier as a System"**
- **Consider how we do business today and should that change for the future**
- **Identify potential soldier performance "leap-aheads" and enabling technologies**
- **Consider psychological and physiological interfaces**
- **Assess science and technology: is it good enough**

Below is an excerpt from a letter dated January 29, 1991 to Dr. Duane Adams, Chair, Army Science Board from Stephen K. Conver, Assistant Secretary of the Army (Research, Development and Acquisition) (see Appendix A). The Terms of Reference directed the ASB Soldier as a System Summer Study Panel to:

- Assess the existing Research, Development and Acquisition (RDA) process for items of materiel for the soldier and compare it to the RDA process for other types of systems. Report conclusions regarding the effectiveness of the existing process, identifying advantages and disadvantages. Recommend a best management and organizational approach for the RDA of soldier materiel. Should the soldier be managed as a major system? Particular attention should be paid to achieving integrated, coordinated, and synergistic RDA of separate items toward overall optimization of the ensemble of the soldier and his materiel.

- Within the doctrinal context of the AirLand Battle-Future (ALB-F) concept and TRADOC-defined required battlefield capabilities, and considering the Soldier as a System (i.e., as defined in the Soldier Modernization Plan) identify potential materiel and training solutions that must be developed to ensure the lethality, command and control, survivability, sustainment, and mobility of the future soldier. Also assess the psychological and physiological interface of the soldier with proposed Soldier System component solutions. Address these solutions to three soldier variants: dismounted, crew mounted (air and ground), and all others.

- For each potential materiel and training solution, assess the state-of-the-art and availability of technologies to implement it; recommend research most likely to produce required implementing technologies; and identify the time frame for implementation.

- Rank-order each potential materiel or training solution and its implementing technology.

We looked at all processes. We considered the changing nature of the threat and current technologies and development programs.

We concluded that one must consider the soldier "skin in" as well as "skin out," as we assess the cost/benefit of the soldier performance leap ahead technologies.

Generally speaking, we have the science and technology, the need is to get science and technology resources focused on Soldier System performance.

Limitations of time and resources restricted the level of detail and scope that could be explored, and focused the ASB on the dismounted soldier as a representative example of all soldiers. Late in the study, quality of life on the battlefield was added as an element of what the ASB refers to as an "Extended Soldier System."

Moving the soldier of today to the enhanced capabilities of the future - is the purpose of the ASB Summer Study.

Participants

Chair: **Dr. Richard Haley**
Vice Chair: **Dr. Joyce Shields**

MEMBERS

Dr. Crystal Campbell
Dr. Gerald Godden
Mr. Marvin Holter
Dr. Walter LaBerge
General James Lindsay
Mr. Charles Malone
Dr. Bruce Montgomery
Dr. Edward Powers
Dr. Robert Weigle
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SPONSOR
LTG August Cianciolo

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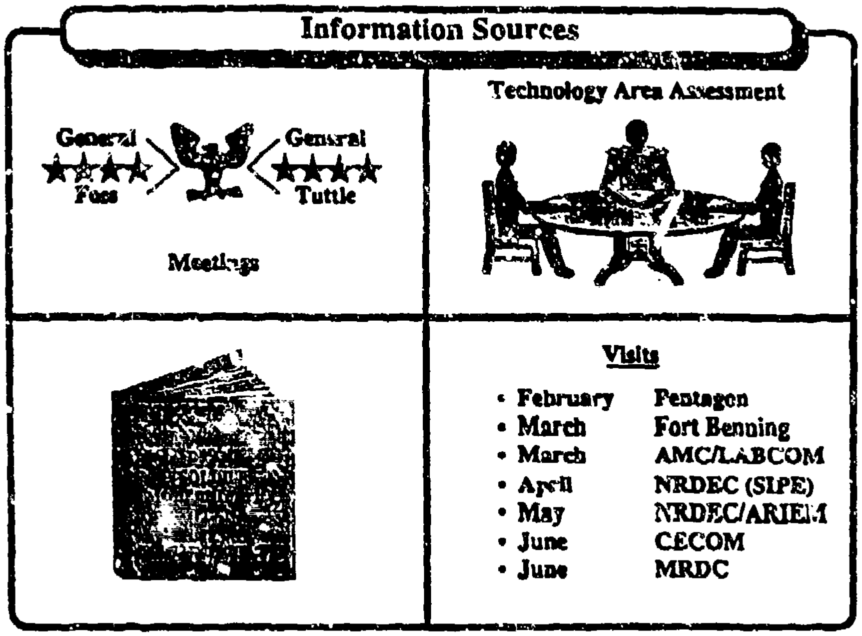
Mr. George Singley III

STAFF ASSISTANT
Ms. Sharon Vannucci

The participants in the study brought professionalism and direction to the task assigned. They came from industry, universities, and private consultants. Some of the consultants had been senior government executives/military officer.

We received outstanding support from active duty personnel from the Army Materiel Command, Colonel Rick Grube; Training and Doctrine Command, Colonel Dean Anderson, Medical Research and Development Command, Colonel Ron Sedge and Colonel Dave Schnakenberg; and the Special Operations Command, LTC Phil Hamilton. The staff assistant from Department of the Army provided superb support for the study group.



The Soldier System Summer Study Panel gathered data from a variety of sources including a number of site visits and several key documents. The Study Panel met approximately once a month from February through July 1991, and Panel subgroups made visits to several organizations focusing on specific aspects of the Panel's investigation.

The introductory meeting was held in the Pentagon. LTG Cianciolo, the Study Sponsor, challenged the members to look closely at the requirements development process and the application of normal acquisition rules to soldier equipment. The members also heard briefings from the Army staff and both user and materiel developer representatives. Subsequent visits were geared to specific aspects of the study's scope. The first March meeting, at Fort Benning, centered on the Training and Doctrine Command (TRADOC) and its methods for establishing soldier-level requirements for different soldier types on the battlefield. COL Anderson, the newly appointed TRADOC System Manager (TSM) - Soldier, presented a preliminary assessment of his role within TRADOC as the integrator of requirements among TRADOC schools. Representatives from various TRADOC schools as well as from the Special Operations Command (USSOCOM) and the materiel and medical development community made presentations on the threat to the soldier as well as other issues of requirements development.

The second March meeting was held in conjunction with the Army Materiel Command's (AMC) Technology Area Assessment (TAA) for the Individual Soldier, an in-depth review of the technology base program for the Soldier System. The ASB heard briefings on the tech base programs of AMC, the Medical Research and Development Command (MRDC), Special Operations Command, and the Army Research Institute. Briefings were grouped according to the five functional areas defined by the Soldier Modernization Plan (SMP). The purpose of TAA was to "maximize synergies through coordination of technology efforts necessary for future soldier systems." For the ASB members, TAA provided a relatively detailed description of the technologies being pursued by the Army for the Soldier System as well as the investment strategies underlying these plans.

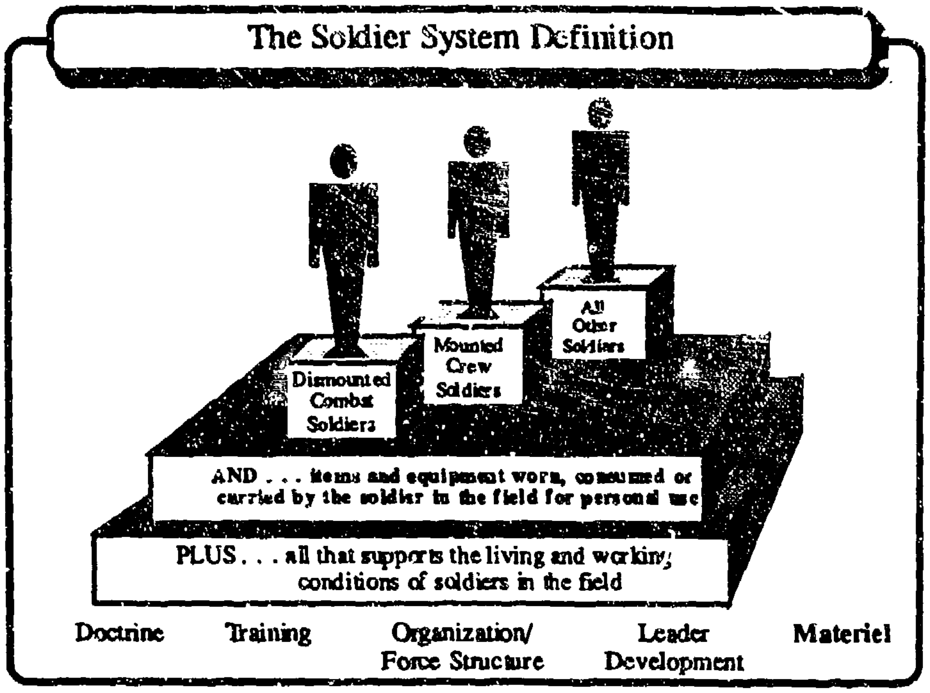
The forth and fifth meetings of the Study Panel were hosted by the Natick Research, Development and Engineering Center (NRDEC) in May and the Communication-Electronics Command (CECOM) in June, respectively. The focus of these visits was on technology and the related research development and acquisition processes. The members heard presentations from NRDEC, two organizations of MRDC, the Project Manager for Night Vision and Electro-Optics, and AMC's Laboratory Command (LABCOM). In conjunction with the NRDEC visit, a subgroup of the Panel spent one full day with the manager and staff of the Soldier Integrated Protective Ensemble and were briefed on the Advanced Technology Transition Demonstration (SIPE-ATTD). Also in June, another subgroup visited MRDC at Fort Detrick for in-depth discussions on medical programs and their relationship to other individual soldier materiel development activities and requirements.

There is a lot going on with respect to the soldier. The new emphasis seems to have started in the Spring of 1988 when all key players were involved in tech base war games that have continued since then. The soldier's performance really does makes a difference.

In January 1990, the Commanding General of TRADOC, General Foss, and the Commanding General of the Army Materiel Command, General Tuttle, started to have semi-annual reviews of soldier issues. These reviews activated their commands to seek solutions to the soldier issues.

Another on-going action of about two years is the development of a draft Soldier Modernization Plan. It defines the Soldier's future needs in the areas of lethality, sustainment, mobility, survivability, and command and control. It looks at four periods of time: FY 91-93 (current), FY 94-97 (mid-term), FY 98-2006 (Block I soldier), FY 2006- and beyond (Block II soldier). Approval of this draft SMP would establish the concept of Soldier as a System and influence the next revision of the Army Technology Base Master Plan.

While at Fort Benning we discussed soldier issues with NCOs attending the NCO school and Captains attending the Infantry School's advance course. We later discussed soldier issues with the old and new Sergeant Major of the Army.



The Soldier System is in transition and still developing. As currently defined, the "Soldier System" consists of the individual soldier and items and equipment which the individual soldier wears, carries or consumes for his or her personal use. In July 1991, the Chief of Staff of the Army enlarged the definition to also include all that supports the living and working conditions of soldiers in the field. Notwithstanding its current focus on items for personal use, the scope of the Soldier System recognizes that the Soldier System perspective must also encompass doctrine, training, organization and force structure, and leadership development. However, the Soldier System definition explicitly excludes materiel required for unit mission purposes, equipment which may be part of the soldier's load but not materiel for his or her individual use, e.g., crew served weapons/munitions, unit radio.

Although the ASB study focused on the dismounted infantry combat soldier as an illustrative soldier-type, there are other types of soldiers, both crew-mounted (air and ground) and support soldiers. Each of these, with their related clothing and equipment, constitute a "Soldier System" which may vary in detail but which, overall has a substantial common core of materiel requirements justifying an integrated Soldier System management approach and perspective.

The Special Operations Forces (SOF) contain dismounted combat and crew soldiers with special mission assignments. While requirements for much of the SOF-Soldier materiel is identical to that required by the dismounted and crew infantry soldiers, the SOF Soldier also has a significant number of unique requirements related to SOF-peculiar missions. Therefore, the managers of the two acquisition systems, Army Soldier System and Special Operations, must at a minimum coordinate their requirements and RDA activities to achieve overall optimization of the soldier ensemble.

The Complexity Challenge

Managing and integrating the Soldier System

- **Multiple programs**
- **Multiple organizations**
- **Multiple systems**
- **Multiple technologies**
- **Multiple kinds of soldiers**

All the multiple components of the Soldier System – the programs, organization, systems, technologies, and soldier types -- interact and interrelate. Although the component elements – materiel worn, carried or consumed by the individual soldier – are not as tightly interrelated as they would be in a traditional equipment "system," nonetheless, the interrelations and interactions among the elements are sufficiently linked both in purpose and function (and aggregate funding expenditures) to justify treating this aggregation as an integrated major system. The estimated funds spent by the Department of the Army on the components of what we have defined as a "Soldier System" is $278M a year in R&D and $718M plus quality of life dollars in procurement. In short, a major system.

The justification for treating the Soldier System as a major system with integrated management perspective, although potent, must not overlook the difficulties of such an approach. The Soldier System must manage complexity of a high order. Multiple layers of organizations and players affect the requirements definition process and the related development and acquisition of soldier system equipment and clothing. The relationships and interactions of the soldier with his/her associated clothing and equipment are looser and more adaptive than traditional equipment systems, but this flexibility facilitates the performance of a multitude of different functions. Also, the Soldier System must explicitly respect the fact that not all Soldier System items worn or used by soldiers are necessary to perform each soldier-function, and, therefore, the collective impact that the weight of such items have on the soldier's functional effectiveness must be incorporated into the analytic perspective.

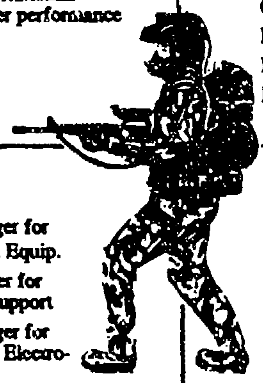
The Complexity Challenge

Technology Laboratories/Organizations

MTL	– Advanced materials
HEL	– Human factors, compatibility
AMSAA	– Simulation/modeling of systems
MRDC	– Assessment and modeling of CIE, rations and environmental impacts on soldier performance

R&D of Subsystems

CRDEC	– Chemical masks/detection
ARDEC	– Weapon
EDTL	– Micro-electronics/batteries
HDL	– Acoustic augmentation
CECOM	– GPS, electro-optics, C^3
BRDEC	– Power, water purification
NRDEC	– CIE, food
MRDC	– Medical protection, sustainment



Management Organizations

PM-CIE	– Program Manager for Clothing & Ind. Equip.
PM-ALSE	– Product Manager for Aviation Life Support
PM-NVEO	– Program Manager for Night Vision & Electro-Optics
USATAP	– Materiel Management of Clothing Items

Materiel

CIE
C^3I
Chemical equipment
Individual weapon
Medical
Food, water

ARDEC	Armaments Research, Development and Engineering Center
AMSAA	Army Materiel Systems Analysis Agency
BRDEC	Belvoir Research, Development and Engineering Center
CECOM	Communication-Electronics Command
CIE	Clothing and Individual Equipment
CRDEC	Chemical Research, Development and Engineering Center
C3I	Command, Control, Communications and Intelligence
ETDL	Electronic Technology and Devices Laboratory
HDL	Harry Diamond Laboratories
HEL	Human Engineering Laboratories
MRDC	Medical Research and Development Command
MTL	Materials Technology Laboratory
NRDEC	Natick Research, Development and Engineering Center
PM-ALSE	Product Manager-Aviation Life Support Equipment
PM-CIE	Project Manager-Clothing and Individual Equipment
PM-NVEO	Project Manager-Night Vision and Electro-Optics
USATAP	US Army Support Activity at Philadelphia

NRDEC is not the only player. The message here is that there are many players, and they have been doing things for the soldier, individually, for a long time and have strong advocacy groups. Generally, however, they have been doing things separately even when in the same command. Actions currently underway are changing that. It is a strong recommendation that they need to be integrated and managed as a system.

Conclusion

Manage the soldier system as a system

While acknowledging that achieving an integrated systems management perspective for the Soldier System will not be easy, this Army Science Board Study Panel believes it is a necessary precondition for facilitating the transition from the Soldiers of Today – with all their present capabilities – to the Soldier of Tomorrow – with future soldier capabilities embedded in new missions, roles and functions.

The Soldier of the 21st century will be acting in a new environment. The tools of soldiering (i.e., the technologies supporting command and communications, mobility, lethality, survivability and sustainment) are so different that the very nature of warfare and threat, and ultimately even the strategies of defense and offense, may be radically altered. As a consequence of enhanced capabilities, the mission, role and function of today's soldier will be significantly enlarged and changed. As we move forward, we must match technology vision with the soldier's inherent capabilities and maximize the future potential of both.

To assist this transition process, new approaches must provide an integrated focus for tradeoffs and capability analyses – review the interactions between soldier, soldier systems and soldier materiel – to realize and develop the power of the future soldier. The desired "system" approach must consider the Soldier System items – materiel and non-materiel – and evaluate the research, development and acquisition (RDA) of these items in light of three critical relationships and related tradeoff analyses: (1) the functional interaction between soldiers and their clothing and individual equipment; (2) the functional interaction of the equipment components, which must operate alone or together; and (3) the interaction between soldier-performance, equipment weight and total soldier-carried load. The need for this perspective – both integrated and modular – provides the justification for and a framework around which the Soldier System must be built.

Issues

(1) Requirements
- Threat Analysis and Capability Needs

(2) Research, Development and Acquisition
- Technology Guidance and Acquisition Planning

(3) Integration
- Focus and Ownership

(4) Architecture
- Integrated and Modular

(5) Technology Assessment
- Value and Availability

(6) SIPE (Soldier Integrated Protective Ensemble)
- Technology Capability Demonstration

Six issues emerged as the core of the Soldier System concept. They are:

Requirements:

The requirements which soldier performance and materiel must meet should be derived from the functions soldiers must perform in the face of the threat on the future battlefield. The process by which this derivation is accomplished is the Concept-Based Requirements System (CBRS) methodology. This derivation has not been completed and must be accomplished in order to guide materiel procurement and training within the future Soldier System.

Acquisition:

At present, in the absence of formally derived needs and requirements, the research, development and acquisition process tends to be driven by the available technologies. As soon as possible this technology-push needs to be supplemented and balanced by the influence of needs and requirements.

Integration:

To assure maximum synergy and optimal soldier performance outcomes, the Soldier System must fuse an integrated perspective with a modular approach in the development and acquisition of soldier items. Since the various items of the soldier's clothing and equipment must interact with the soldier and among themselves, both functionally and in contributing to total weight, tradeoffs among them are necessary. This necessity for tradeoffs requires that the development and acquisition of soldier system items be managed in an integrated manner by a single manager.

Architecture:

Since soldier materiel items interact both in function and in their contribution to the total weight carried by the soldier, it is necessary that these materiel items be structured into an integrated architecture to make these interactions explicit and reveal the item/performance tradeoffs. However, the systems architecture also must encompass a modular concept since not all items will be required for every task and performance advantages may be gained by allowing flexible deletion from the soldier's load of those items not required for the specific task at hand.

Technology Assessment:

Suggested areas of Panel concerns are outlined in Appendices E and F.

SIPE-ATTD:

The Soldier Integrated Protective Ensemble - Advanced Technology Transition Demonstration (SIPE ATTD) is important in two ways:

- First, it experiments with setting performance assessment (goals) above the component level, thus requiring cooperation and coordination among numbers of developers and providers of differing components.
- Second, it involves an assessment of the performance capability of a specific assemblage of components in an architecture called the SIPE. It is important that the specific test design and exit criteria be defined in detail.

ISSUE 1: Requirements

FINDINGS

- **Scenario-based threat analysis applicable to soldier system missions and tasks – are not available**
- **Concept-Based Requirements System (CBRS) through soldier system missions and generic tasks – are not available**
- **Analytic tools (simulation technology) for analysis of soldier system performance requirements – are not available**
- **SOF provides a strong user pull for future Soldier System capabilities**

The Concept-Based Requirements System (CBRS) is a coherent, top down mechanism for developing functional mission requirements needed for the future. However, the current analyses have not been extended to include the anticipated generic tasks of the individual soldier as he meets the future threats. The threat to be used as the basis for these analyses is still to be defined and is also an urgent need.

At the present, CBRS does not adequately address the anticipated missions and generic tasks for the individual soldier along with the expected threat environments in a variety of scenarios in a way which allows definition and prioritization of capability needs.

- The threat information as presented to the ASB is incomplete, not useful and not correlated to the expected missions and scenarios.
- Tools, such as simulation technology, are not currently available to be used as part of the requirements generation process to evaluate effectiveness or facilitate tradeoffs for various combinations of anticipated solutions for the Soldier System.
- The current CBRS documents to which the ASB has been exposed (e.g., AirLand Operations, TRADOC PAM 525-5 dated August 1, 1991) do not properly treat the probable very low density of traditional infantry soldier system missions and the potential for augmenting the Soldier System with Unmanned Ground Vehicle/Unmanned Air Vehicle on the future battlefield.

The Blueprint for the Battlefield (TRADOC PAM 11-9) institutionalizes and standardizes the concept of describing battlefield operations as a combination of mission and generic tasks.

The output of the CBRS process should then be a "set" of documents describing how and with what materiel the generic tasks will be performed in each scenario against the expected threats on the future battlefield. The sets may need to be time specific snapshots of how these functions would be performed in various time frames. This CBRS output would then serve as a frame work which can guide the Tech Base and RDA processes of the Army, and against which the results can be judged. In addition, if the plans (such as SMP) which support the results of the CBRS are judged to be unrealistic or unaffordable, feedback can occur to adjust the "how" and "in what time frame" the CBRS results must coincide with the capability projected by a realistic and affordable Soldier Modernization Plan. At present, the CBRS process has not been completed down to the level at which the capability need requirements for soldier system materiel (SSM) can be derived for the future soldier.

One particularly glaring omission in the information presented to the ASB is a clear description of the threat associated with performance of mission and generic tasks in a variety of operational scenarios. For example, is air superiority assumed? In which mission/scenario?

The important aspect of this is in anticipating the number of soldiers expected to be involved in performance of various generic tasks. The current draft Infantry White Paper (Infantry Branch Concept) appears to anticipate that the tasks and relative "density" of performing those tasks will be similar to past (Vietnam, WWII, etc.) wars. It does not anticipate, for example, that the future battle might be largely fought using precision remote force insertion with only very limited (few instances, not many soldiers involved) SOF-like operations. The trend demonstrated by Desert Storm is that the U.S. Army will, in the future, fight "stand-off" wars in which an increasing percentage of Army personnel will be further from the action, remotely operating long-range, accurate ordnance delivery systems and supported by efficient command and control networks. This kind of war will be more likely to be supported by U.S. citizens. Combatants will target each others' weapons platforms using increasingly more extensive surveillance and targeting systems and communicate this information to fire control points. Classic "charging the hill" maneuvers and tank battles will not be the preferred tactics.

On the other hand, requirements for Special Operations missions in which the dismounted soldier still represents the most significant element of the mission, will likely be maintained or even intensified. In particular, Military Operations in Urban Terrain (MOUT) (not necessarily SOF, but similar in many respects) appears to be an especially challenging mission. It would seem that satisfaction of SOF requirements (being the most challenging) would generally encompass requirements of all other soldiers. In fact, the ASB has found that the SOF and Marines have provided a strong user pull to modernize and advance soldier system capabilities. However, a challenge would be to "modularize" soldier system materiel (SSM) such that use of the same item(s) in multiple missions is cost-effective. Clearly, we have been given examples for which cost/performance tradeoffs are clear problems and can anticipate that rear echelon support soldiers would not need a very expensive, lightweight bulletproof, all purpose "BDU".

The Technology Based Seminar War Games illustrated the potential for evaluating the performance of alternatives to SSM in the execution of mission and generic tasks on future battlefields and indicated high payback for improved SSM. However, these exercises were at too high a level (relative to the individual soldier) and may not have been adequately constrained (e.g., higher or unrealistic capability assumptions with zero detection signature). However, based on a review of current technology done in cooperation with the 1991 Summer Study "Army Simulation Strategy," thoroughly comprehensive tools are not yet available to perform realistic operational simulation at the soldier system level.

ISSUE 1: Requirements

RECOMMENDATIONS

- **Develop scenario-based threat analysis for the future Soldier System**
- **By 1992 complete CBRS analyses through the Soldier System level**
- **Develop and employ war gaming/simulations with emphasis on future Soldier System threats**
- **TSM should more formally and effectively coordinate SOF and other services' requirements and resources**

The completion of concept-based analyses of the threat to be met in the future at the level of the individual soldier and/or small unit operation is an urgent requirement. It is important to provide an adequate range of threats expected in various scenarios. Until this is done, the extension of the CBRS process to the level of the soldier, and in turn the further update of the Soldier Modernization Plan, cannot be completed. Due to the urgency of this step, it is recommended that it receive immediate attention with the recommendation that it be completed in 1992. If this date for completing a sophisticated analysis is judged unrealistic, it is recommended that an interim threat assessment be developed to allow the initiation of the CBRS effort for the soldier and the preparation of the next version of the Soldier Modernization Plan to have a more solid basis.

One way of illustrating the ASB's recommendation is to functionally describe a "matrix" which could be the end product of CBRS for Soldier Systems (see next chart). The left side of the matrix contains the distillation of how the mission and generic tasks would be performed within the operations scenarios expected in the future battlefield, including frequency of occurrence of mission and generic tasks.

The objects of the blocks in the matrix would contain solutions (and associated costs) for various alternatives to achieving the mission and generic tasks. This basic "data base" mechanism would reveal commonality of various solution sets which provides ideas for consolidation of Tech Base and RDA direction, and allows prioritization of various solutions.

SOLDIER SYSTEM CAPABILITY NEEDS MATRIX																	
MISSION/ GENERIC TASKS	THREAT/ ENVIRON-MENT	THEATER SCENARIO	ALTERNATIVE SOLUTIONS/INTEGRATED COMBINATIONS OF SOLDIERS/SOLDIER SYSTEM MATERIAL														
			#1					#2					#3				
			LETHALITY	MOBILITY	CMD/CONTROL	SUSTENANCE	SURVIVABILITY	LETHALITY	MOBILITY	CMD/CONTROL	SUSTENANCE	SURVIVABILITY	LETHALITY	MOBILITY	CMD/CONTROL	SUSTENANCE	SURVIVABILITY

The CG, TRADOC and Deputy Chief of Staff for Intelligence should extend the CBRS down through Branch Concepts for the 1992 Battlefield Development Plan (BDP) including definition of how and with what materiel generic tasks are to be performed by the future soldier within expected threat environments as applied to time frames 1994-1997 and 1998 to 2006; and, thereafter, evolve (revise and staff) the documents every two years to be the basis for SSM development in tech base and RDA processes by providing a list of prioritized capabilities and needs. An important aspect, of course, is that the CBRS process should provide an efficient basis to exploit cost savings associated with:

- avoiding multiple, overlapping development programs and development organizations;
- facilitating large quantity production of common items;
- but, however, avoiding the trap of creating and fielding for all soldiers an expensive "system" of Soldier System Materiel which modularly satisfies all of the Soldier System requirements, when, in fact, only a few soldiers would ever need a significant fraction of the total capability.

CBRS process should include and consider how alternatives to the Soldier System will be used on the future battlefield to perform mission and generic tasks within the expected scenarios and threat environments.

One aspect of TSM-Soldier's responsibility is the total coordination of the broad range of future capability needs across the full range of soldiers including SOF and Marines. In order to assure that all of the capability needs are addressed within a "master" priority list, TSM-Soldier should establish a formalized method to insure that SOF and Marine capability needs are included within the overall priorities and/or influence the overall capabilities.

In order to support the CBRS process, the ASB recommends that the Army continue to develop and use tools, such as simulation and war gaming, to project Soldier System performance on the future battlefield.

The CBRS processes will require new and more powerful tools to permit the simulation of the complex environment and assigned tasks at the individual soldier and/or small unit level. The initial series of war games conducted over the past two years, which brought the users and the technologists together, has shown the value of this approach. However, the simulation methodology currently available does not permit the extension of detailed simulation that will be required to the level of the individual soldier and small unit on a complex battlefield. In developing these new analytical methodologies, it is also important to allow consideration of all options for meeting the needs rather than considering just solutions involving materiel.

The development of simulation technologies which can reproduce and test the effects of the complex environments and the operational issues in which the individual soldier will be expected to perform in the future is judged to be critical for the development of the tools that will permit task and war gaming evaluation. Future efforts to produce CBRS requirements for the soldier and to update the Soldier Modernization Plan heavily depend upon this technology.

ISSUE 2: Research, Development and Acquisition

FINDINGS

- **Soldier capability needs are not available to influence Tech Base investment strategy**
- **Soldier modernization plan (SMP) establishes the concept of the Soldier as a System and provides the initial roadmap for Block I**
- **SMP Block II is not realistic nor funded**
- **SMP is critical to planning process, but is not approved**
- **Difficult to assess total dollars in Soldier System Tech Base (approximately $200 M per year)**

Due to the absence of the availability of a set of Soldier System capability requirements, the current process to prioritize the technology base for the Soldier System has been primarily technology driven. The ASB has found that, nevertheless, the tech base has done a good job of anticipating and supporting advanced capability for the soldier in many areas. However, the ASB had no firm basis for evaluating whether the technology base emphasis or funding correlates to the capability needs of the future soldier.

The current Soldier Modernization Plan (SMP) represents a good initial road map for addressing the concept of the Soldier as a System, and if approved would establish formally the concept of managing the Soldier as a System. However, because of the lack of completion of a current cycle of the CBRS process, the current SMP was not systematically based upon the requirements determining how and with what materiel the soldier will perform the generic tasks within the missions, scenarios and threats projected for the future battlefield. However, even with these discrepancies, the ASB feels that the capability needs for the Block I soldier as identified in the SMP (scheduled for deployment in 1998 - 2006) are realistic and supportable by technology expectations.

The Soldier Modernization Plan's assumptions are that changes will be introduced using the block concept. Conceptually, two very different methods of implementation are possible, Block Change or Continual Modular Introduction of Improved Capability. Although in practice eventual system implementation is often a blend of both concepts, the detailed design of all system elements is profoundly influenced by an initial decision as to which of these two concepts, Block Change or Modular Introduction, is the primary intent. The Block concept for this program is of concern. Further, this ASB Panel feels that by the year 2008 the Block II capabilities that would be preferred may be unrealistic or could potentially be achievable by non-Soldier System alternatives such as unattended ground vehicles and unattended aerial vehicles. Further, even if fielded, the Block II Soldier System would likely be needed in only small quantities to satisfy very unique SOF-like contingencies.

At the present time, there is no specific accounting methodology which identifies what technology base funding is specifically associated with the Soldier System. Therefore, it has been difficult for the ASB to assess the dollar level of the technology base that is being applied to the Soldier System. Information presented at the Soldier System Technology Area Assessment at AMC provided some insight, but was most likely obtained as an after-the-fact estimate of how much money is allocated to various programs which could be related to the Soldier System capabilities. At this point, the best estimate is that there is approximately $200M/year allocated to the Soldier System technology base effort (including medical tech base efforts).

Various lab managers have indicated that there are shortfalls in funding to achieve the technology levels needed to support some perceived, but as previously shown, undefined needs.

ISSUE 2: Research, Development and Acquisition

RECOMMENDATIONS

- **Develop prioritized list of capability needs to influence Tech Base program investment**
- **Reevaluate Tech Base funding in light of capability needs and SMP**
- **Approve current SMP through Block I; revise as appropriate**

A most important output of the CBRS process is a list of prioritized capability needs which can be used to drive technology base activities and funding priorities. The shift to the concept of the Soldier System provides a good basis for striking a balance between technology push and user requirement pull, a balance that would appear preferable for the Army as it moves into an era of downsizing and funds reduction. At the same time this places a high degree of responsibility upon the CBRS system to assure that the user pull does correctly reflect the changing operational requirements. After the CBRS is completed, the Army TRADOC System Manager should re-examine the SMP within the context of the individual soldier capabilities defined in Branch Concepts developed through the CBRS, with a view of incremental improvement while retaining the modular approach to modernization.

When these actions are completed, the needs that will be identified through CBRS at the soldier level and the revised Soldier Modernization Plan will provide an excellent basis for assessing the technology base program. It is recommended that the technology base managers use the CBRS requirements list, when it is developed, and the Soldier Modernization Plan's schedule for development of the "Block I" soldier ensemble as key documents for establishing, prioritizing, funding and managing the supporting technology base efforts that will be needed for the "Block I" ensemble. With this as a basis, it is recommended that the technology base programs be revised where needed, including the reassignment of funds, to meet the capabilities and schedules which will be needed for the Block I. This is the next major critical integrated step in meeting the expectations of the Soldier Modernization Program.

It is recommended that the Soldier Modernization Plan be modified quickly to:

- Officially include only the Block I phase, and
- Accommodate whatever soldier system management changes have been or will shortly be made as a result of this ASB study.

It should then be approved through the Block I phase, even though it is recognized that there is still much to be added in future versions of the document. Our review demonstrated that the Army needs this milestone approval to get the concept of the "Soldier as a System" recognized and accepted within the Army. It will help "jump start" the effort and send a strong message on the importance of the soldier.

At the same time it is recommended that the SMP should be considered a dynamic document that will require regular attention and incremental revision as the concept matures. It is our feeling that "Block Changes" should be avoided wherever possible, and only adopted when a change of capability is absolutely required which outmodes almost all other elements of a system. It is not obvious that such a system exists within the Soldier as a System program. This Army Science Board Study recommends a Modular Introduction concept be employed rather than a Block Change concept, because it may be preferable in an engineering and operational sense. Further, Modular Introduction may be inevitable as a consequence of budget limitations and surge requirements and the need to incorporate new capabilities quickly as technology advances provide opportunities.

Although not highlighted in "The Findings and Recommendations," additional significant observations are discussed below.

The system for acquiring integrated "Soldier System" equipment presents a serious challenge for the current acquisition system. The ASB study Panel evaluated the current acquisition process as a basis for judging whether the current system would need to be revised to meet the challenges for the provision of the integrated, modular and incrementally improved soldier ensemble envisioned for the future. Several issues were identified during the review that would require attention to prepare the current system for what is projected to be needed during the transition to the integrated "Soldier System" of the future. The findings and recommendations are discussed in more detail in Appendix B, but a summary follows:

The increasingly complex CIE for the Soldier System needs to be treated more like a hardware system than individual clothing items, and its development and acquisition (particularly through the production readiness demonstration) need to be done under the Army management rather than through DoD's Defense Logistics Agency.

The recent experience in Desert Shield/Storm indicates that there is a lack of adequate planning for how much and what quantities of Soldier System materiel needs to be available (stocked) for use in large scale contingency deployment. This supports the need for central planning, acquisition, and fielding of SSM.

In response to the recognition that the current acquisition process is unable to respond to meeting the unexpected and the contingency needs of the CINCs, the Army has established two programs which have been quite successful. They are the Soldier Enhancement Program (SEP) and the Field Assistance in Science and Technology (FAST).

SEP comprises funds managed at HQ Army to procure a wide variety of items to satisfy urgent soldier systems needs. Within FAST, the Army Materiel Command subordinate commands provide representatives to the CINCs to enable a direct channel to communicate capability limitations and deficiencies to the R&D commands. These programs are discussed further in Appendix C.

These programs are working well and should be maintained; however, the TSM-Soldier should channel information from SEP and FAST into the prioritization of capability needs.

ISSUE 3: Integration

FINDINGS

- **All items of soldier material are interdependent**
- **No management mechanism for critical trade-off analyses**
- **No central organizational focus - limited power to affect system outcomes across programs/organizations**
- **Tech Base Executive Steering Committee coordinates program but is too narrow in focus**
- **Scope of TSM-Soldier job greatly exceeds normal TSM responsibilities; sufficient resources not yet dedicated to assure Soldier System future**

Integration is a critical issue. As was noted earlier, the management of the Soldier System presents an issue of complexity as well as one of integration. There are many Army laboratories and centers engaged in developing component items which are part of the Soldier System. Additionally, there are several project managers, other materiel oriented technology laboratories, a number of medical laboratories and the Army Research Institute, all contributing to the soldier's benefit, with many charged with a responsibility to develop items of equipment. Examples of those activities are as noted in a previous chart entitled "The Complexity Challenge."

Most significant is the fact that a large percentage of their efforts involve Soldier System hardware development, much of which should be developed in an integrated and modular fashion. As noted in our findings, nearly all items of soldier materiel are interdependent and therefore should be subject to system development rules. However, this has not been the case and, in fact, has never been the case. Yet in most instances, the soldier's equipment does fit together and operates properly. Nevertheless we believe an inordinate expenditure of resources is required just to coordinate equipment interfaces across and up and down organizational lines of authority.

There is simply no central organizational focus for the Soldier System, and therefore the ability to perform realistic system trade-off analyses which can influence system outcomes is extremely limited. Each developing organization may be doing an adequate job of optimizing their equipment component, but there is no opportunity to perform such a function on a system-wide basis. We also have a concern that focusing on separate equipment items results in an organization-by-organization determination of what technology to support. The opportunity to pool resources to bring a technology to fruition which would be of benefit to two or more Army organizations does not appear to happen significantly often. Thus a limited dollar resource is not always used most effectively.

This raises the issue of the coordination role of the AMC Tech Base Executive Steering Committee. It is a coordinating committee and not a management committee, and it is somewhat narrowly focused on concerns that are materiel oriented. Strides have been made in bringing representation from the OTSG and ARI to provide a benchmark and a base from which to expand these interests. This does have the potential of establishing a number of technology integration opportunities that would not have been possible without such a relationship.

Lastly, it should be pointed out that the TRADOC System Manager (TSM) for the Soldier has much broader responsibilities than those of other TSMs. The TSM-Soldier has been charged by the Commander TRADOC to be the conscience of the Army for the soldier. His integration responsibilities for the individual soldier extend across-the-board to include dismounted, mounted and all other soldiers, and therefore he must maintain strong interfaces with all other TSM's in integrating the requirements for the individual soldier. The TSM-Soldier also interfaces with the technology base community through his membership on the Technology Base Executive Steering Committee which was formulated originally within the AMC community. Recently, the Chief of Staff has high-lighted the need to improve the quality of life of the soldier in a tactical environment, and this responsibility has also been assigned to the TSM-Soldier. With all of these responsibilities, there is a question as to the ability of the TSM-Soldier to effectively perform all these functions within existing manpower resources. As a final observation, a complete identification of these resource needs has not been completed, and to date, the TSM-Soldier has been fully supported based upon his specific requests.

ISSUE 3: Integration

RECOMMENDATIONS

- **Appoint a General Officer Manager to integrate Soldier System acquisition; restructure within existing resources**
- **Establish a focal point in SARDA to manage the Soldier System Tech Base program**
- **Establish and resource a "unique" TSM for the Soldier System in TRADOC**

There is an overwhelming need for a General Officer Manager of the Soldier System. It is absolutely essential that the soldier and all of his equipment be managed as a system to assure the necessary trade-off analyses can be made to provide the soldier with the most effective capability within all the constraints of weight and physiological performance limits that must be met. We found no existing mechanism by which such trade-off considerations can be effectively made and implemented because there is no single manager of the Soldier System. An immediate advantage of having a Soldier System manager is that he would have control of the funding authority and thus would be able to fully implement changes derived from the trade-off analyses. Furthermore, we believe it is totally necessary that the Soldier System manager institute procedures to assure that all sub-system components are integrated, that these sub-systems be completely modular, and that a configuration control methodology is implemented at the outset to guarantee an integrated, modular system result.

We recognize that Army manpower resources are shrinking, and this must be a strong consideration in creating a Soldier System management organization. Such an organization must be lean in terms of staff and should not exceed a total of 20-30 people at a maximum. These resources should be assigned from the several organizations currently responsible for the development and equipping of the soldier.

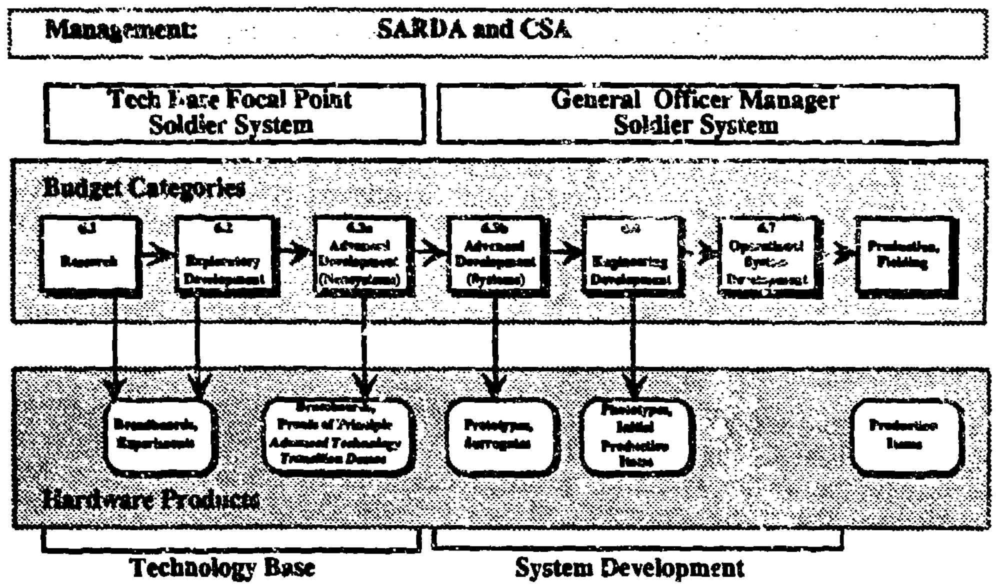
It is uncertain as to the adequacy of funding, but our view is to establish the Soldier System Manager with existing resources assigned. As that staff becomes operational, the funding issues must be dealt with as they are identified. Since the Soldier System Manager should have reprogramming authority, it will be possible to begin to make judgments based upon a across-the-board trade-off analyses. Thus, the Soldier System will begin to evolve towards the premise of providing the soldier with the best capability possible within available resources. As over-riding needs are identified, the General Officer Soldier System Manager will have the rank to at least be able to compete for these resources. The infantry soldier is the only combat arm that does not have a PEO advocate for his needs.

A focal point, to provide SARDA management oversight for the soldier technology base is also needed to assure the funding assets required to support soldier interests within the AMC, OTSG and ODCSPER are appropriately adjudicated. While it is recognized that a prioritization of the tech base programs within each of these communities occurs, it is likely that a good solid across-the-board evaluation of priorities among these three performing activities has not happened. It is important that this be done to assure the most efficient utilization of those funding resources.

It is also a concern that the external technology community has not played a strong role in the evaluation of the Army's technology base program, and we believe this is a shortcoming that should not be overlooked. They must be routinely invited to meetings and asked for comments. Seldom are Army resources/funds available to leverage and transition technologies from external sources. Available technology from other of the government agencies (DOE, NASA, NIH, etc.), as well as industry should not be missed and should become a part of SARDA soldier technology base considerations.

The TSM-Soldier has more assignments than can be effectively addressed within the resources normally assigned by TRADOC to a TSM. The across-the-board assignments to serve as the Army's conscience for the soldier, assure the quality of life of the soldier in the field, be the tech base advocate for the soldier while performing all the other activities of the usual TSM office is considerably broader than that of any other TSM. In addition, there is an added function which we believe the TSM-Soldier should perform with either organic assets or with external resources. As the individual soldier requirements begin to evolve from the CBRS process, interface problems will arise between the capabilities needed to address these requirements. System engineering principles must be applied in adjudicating overlapping requirements to assure that the stated required operational capability has been integrated and that all related requirements have been appropriately considered. This unique TSM must be recognized and staffed accordingly.

Acquisition Management Relationship (Future)



The Tech Base Focal Point at SARDA would manage the integration of 6.1 Research, 6.2 Exploratory Development, and 6.3a Advanced Development (Nonsystem) programs in support of Soldier System.

The General Officer Soldier System Manager would manage the integration of 6.3b Advanced Development (Systems), 6.4 Engineering Development, and 6.7 Operational System Development programs and be responsible for production and fielding. It is a big job.

Why General Officer Manager is Essential

Management Challenge

- Multiple program control
- Organizational complexity
- Integration of technology advances
- Major interface controls required
- Long term mission

Required Capabilities

- Tradeoff analysis among interrelated programs
- Reprogramming authority to implement tradeoffs
- Responsibility and authority to field integrated Soldier System

Programs

- Clothing
- Individual equipment
- Food
- Chemical/biological and ballistic protection
- Field services
- Individual weapons
- Communications
- Training

Funding

- Large dollar volume

	FY92-99	FY00-08
RDTE =	$278M	$347M
PROC =	$718M + ?M	$2,255M (Block I)

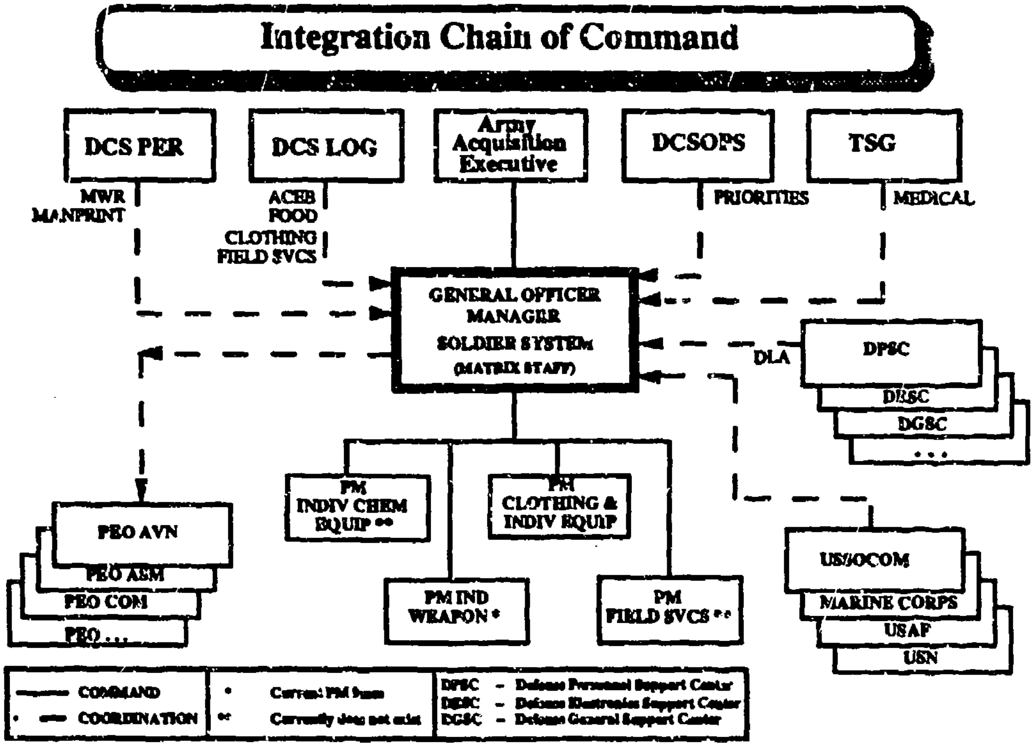
Quality of life

- Funding integration
- Leverage
  - Joint services
  - Industry

A general officer manager is essential because of the management challenge, the multiple programs, the complexity of achieving the required capabilities, and the large amount of RDTE and procurement funding now and in the future for soldier systems.

When the Army made a decision to acquire a capability in the 1970s (Big Five), it appointed General Officer Managers for the Advanced Attack Helicopter (AAH now Apache); Utility Transportation Aircraft System (UTTAS, now Blackhawk); Surface-to-Air Missile Development (SAM-D now Patriot); Experimental Model One (XM-1 now Abrams); and Mechanized Infantry Combat Vehicle (MICV now Bradley).

We need to do the same things for the Soldier System today. We need to have a general officer manager who performs the functions similar to a more traditional hardware PEO.



Any organization that is provided to the General Officer Manager must have a matrix staff with membership representing a direct link to DCSOPS, DCSLOG, DCSPER, TSG, DLA, USSOCOM, and other appropriate agencies, such as the Marine Corps.

In addition, he must manage and have control over individual chemical equipment, clothing and individual equipment, field services, and individual weapons.

Key materiel components of the Soldier System are listed below.

MATERIEL COMPONENTS OF SOLDIER SYSTEMS

Clothing & Individual Equip
- Ballistic Protection
- Environmental Protection
- Chem/Bio Protection
- Gloves
- Boots
- Helmets
- Ballistic/Laser Eye Protection
- Sleeping Gear
- Entrenching/Traversing Equip
- Camouflage
- Portable Lights
- Survival Equipment
- Load Carrying Equipment
- Compass

Chemical Equipment
- Respiratory Mask
- Sensor/Detector
- Personal Decon

Individual Weapon
- Personal Weapon
- Sights
- Interface W/C3I
- Grenade
- Bayonet

C3I
- Individual Radio
- Position Location
- Decision Aids/Display
- Data Base
- Night Vision

Medical
- Vision Correction
- First Aid Kit
- Preventive Medicine

Food Water
- Operational Rations
- Heating Equipment
- Water Purification

ISSUE 4: Architecture

FINDINGS

- **An integrated modular architecture is essential to coordinate and focus the Tech Base and development efforts**
- **Lack of systems engineering methodology**
- **Many examples of equipment interface mismatches**

The ASB saw several examples of an emerging architecture. The broad extent of components centered around the individual soldier, combined with the range of global theater defense missions, lead to a complex system that is challenging to define and manage. The stereotypical notion of a single solution or ensemble is quickly dispensed. A more detailed breakout of the current clothing and individual equipment component of the Soldier System is presented in Appendix D. When the spectrum of missions, combat theaters, and individual differences are considered, the list of Soldier System items readily extends into the thousands.

Agreement upon an overall architectural plan for the Soldier System is required before appreciable progress can be made in the focus of technology options toward support of the future Army soldier. Achievement of an approved architectural definition should be placed high on the list of immediate tasks facing the management of the Soldier System.

By architectural design, we mean a) a substantive definition of the elements within the Soldier System and a definition of how each of these elements is to interface with each other, b) a substantive definition of the primary elements outside the Soldier System with which the soldier must deal and a companion definition of these required interfaces, and c) a reasonably complete definition of the expected implementation concepts for fielding, both in timing of individual element introduction and in the ability/inability to use in part or mix/matched with existing inventory items.

It appears to us that definition of the closely interlocking individual elements within the Soldier System and those outside cannot be made without a systems engineering methodology, even at this early conceptual stage. Having an architectural design prior to a detailed component design effort has long been required in Army implementation of major acquisition systems. It is an obliged element of Concept Design Reviews and is widely practiced. However, such formal systems engineering methodology seldom has been required for component advanced development.

Since the Soldier System is a relatively new concept within the Army, there naturally has been little opportunity to apply a system engineering methodology. System engineering establishes the desired requirements: defines a system architecture specifying form, fit and function of the elements to ensure compatibility and interchangeability of the parts, and maintains the configuration in documentation available to all contributors to the development and provisioning activities. We found little evidence of this basic methodology. Aside from the notable example of SIPE to bring several new protective components together in an integrated modular fashion, there has been no systematic approach beyond the level of engineering interfaces between the soldier, his equipment, vehicles, and weapons.

Intrinsic to the notion of a system approach is an integrated modular ensemble of equipment and consumables. Integration and modularity may at first appear to be opposing concepts. On one hand, a tightly integrated system tailored to a specific function can not be easily modified by changing components. On the other hand, the current soldier equipment ensemble is highly modular, but not well integrated. Integration must not lead to an overly rigid configuration (a potential outcome with a dogmatically pursued Block change/platform approach). Integration of the soldier-borne equipment taken to excess will undermine the key strength of the soldier, that is his or her capacity to respond flexibly to varied situations. The soldier does not need to carry all items all the time. The architecture must incorporate and promote the concept of interactive modularity among soldier items. A balance between integration and modularity must be the goal for the Soldier System.

In particular, one of the most important of these driving SMP assumptions is that of how the evolving components of the Soldier as a System are to be introduced into field use. Conceptually, two very different methods of implementation are possible Block Change or Continual Modular Introduction of improved capability. Although in practice eventual system implementation is often a blend of both concepts, the detailed design of all system elements are profoundly influenced by an initial decision as to which of these two concepts, Block Change or continual Modular Introduction is the primary intent.

Mismatches

- **Internal to Soldier System**
  - **M16 rifle, chemical mask and ballistic vest interference**
  - **Extreme cold weather parka did not fit over helmet**
  - **Dust goggles/helmet interference**

- **External to Soldier System**
  - **Chemical rubber gloves too stiff to tune radios**
  - **Combat vehicle helmet electronics incompatible with vehicle intercoms**

The ASB learned of several equipment mismatches. The key examples cited above, we have been told, have caused serious reduction in the soldier's fighting effectiveness and in his or her quality of life. The purpose of this chart and its discussion, however, is not in any way meant to be accusatory of designers nor any specific organizations. Rather, it is presented to emphasize the importance of applying to the Soldier System the same standard system engineering techniques used by the Army in its other major system developments. Our presumption is that the advanced technology nature of the components, the divided responsibilities for procurement, and the very early state of planning for an integrated Soldier as a System has been responsible for not having a framework to prevent these "mismatches".

Examples of several mismatches are listed below:

- One simple, but pertinent one is the design of the interface of the augmented helmet system with the postulated soldier integral computer system. If one were to always implement the two together, then one might (as is the current assumption) load the majority of all the electronic calculations in the computer. If, however, the helmet was to be used when the computer was not available, a conventional integral processing within the helmet is straightforward at probably no appreciable increase in cost.

- Another example of a mismatch is the failure of the soldier protective ensemble to allow effective target acquisition and firing of current and future crew served weapons.

The examples above and the items contained in the "Mismatches" chart are reasonably well known to the Army community. They are a small sample of a somewhat larger list compiled from discussions with the many organizations and people with whom the ASB team talked. These examples illustrate the difficulty of ensuring compatibility in soldier equipments and the necessity of a rigorous process to achieve that compatibility.

ISSUE 4: Architecture

RECOMMENDATIONS

- **Develop family of integrated, modular equipment and consumable items for the Block I soldier, tailored across a spectrum of concept-based missions and tasks**
- **Apply systems engineering methodology, assure integration, and coordinate Tech Base, development and user communities.**

A principal goal of the Soldier System program should be to develop a family of integrated, modular equipment and consumable items for the Block I soldier, tailored to answer a spectrum of concept-based missions and tasks. The level achieved will be a limited core of common equipment and provisions for the distinct climatic regional theaters the Army must be prepared to operate in. At a minimum, three climate/region ensembles are envisioned: winter, forest/jungles, and desert. While it is useful to identify the common core of equipment and provisions, and to ensure their compatibility with each of the ensembles, in reality there will be more different than common items.

It is crucial that the TSM-Soldier coordinate, within an overall formal architectural plan, a joint TRADOC/RDA team approach to ensure compatibility of equipment proposed for delivery to the soldier. Enduring compatibility becomes much more difficult in the modular approach to implementation than we propose for Soldier as a System. With the concept of frequent major block changes, compatibility is considerably more easily handled. However, as we have already said, we believe that frequent block changes are unrealistic for many reasons, and, therefore, ongoing piece-part compatibility of soldier equipment is of dominant importance. We encourage the Soldier as a System program to implement these measures as a matter of urgency.

We believe that it is necessary for Army authorities to establish an objective unit cost for the combination of equipments which will constitute the Block I Soldier System. We recognize that this objective cost may have to be modified in the light of additional user priorities and better understanding of costs. However, we believe there to be a potential affordability issue not yet adequately addressed. The design of the Block I system will necessarily be affected by a realistic assessment of the quantities required and monies expected to be available for procurement. Our first impression is that the Block I soldier equipment suit and its planned improvements may well constitute a larger funding commitment than can be afforded by the new austere environment anticipated in the future. The character of the very early R&D program is in major measure determined by these affordability considerations. Therefore, we strongly suggest that the TSM lead a team from various elements of the Army to make an initial cut at this objective cost.

The ASB strongly suggests that the concept of a Block Change, intrinsic to the current SMP, be quickly reviewed. On the basis of what it now knows, this ASB Panel believes that a Modular Introduction rather than a Block Change concept is both preferable in an engineering and operational sense, and further that Modular Introduction will be inevitable as a consequence of budget limitations and surge requirements.

Traditionally, soldier equipments have been "mix and match", reflecting the unique requirements of various units, their current state of equipage, inventory availability, and allocable resources. Historically, readily identifiable major transitions in soldier uniforms and equipment have occurred about every two to three generations, i.e., Revolution Continental Army, Civil War, WWI,WW II, and Viet Nam.

Even if such a Block Change was possible, we feel that adopting that concept would be a bad idea. Our collective experience has been that Block Changes force the soldier to wait for the last of the technological capabilities to be completed in order to benefit from any of the capabilities in the Block. This difficulty will be exacerbated in the future budget-restricted environment. Further, the concept of Modular Introduction allows a far greater opportunity to utilize components in the many different missions of Army soldiers, both within regular Army elements and within the SOF. It is our feeling that Block Changes should be avoided whenever possible, and only adopted when a change of capability is absolutely required which outmodes almost all other elements of a system. It is not obvious that such a system exists within the Soldier as a System program.

Resolution of the preceding issue is critical to the current focus of the Soldier as a System technology program and to any planning of field introduction. Therefore, we suggest an immediate review of this issue and a broad promulgation of Army implementation intent.

A system engineering methodology must be thoroughly thought out and implemented via future revision to the SMP. A system engineering approach to defining (threats, requirements); designing (function, allocating interfaces, requirements, flowdown, tradeoffs); controlling (configuration management); testing; and managing represents a significant paradigm shift compared to the past approach covering thousands of items which were extensively treated as isolated entities. Clearly the system engineering approach applied to complex hardware and weapon systems can not be dogmatically pursued. Individual differences, cultural traditions associated with soldier equipment and consumable items, economic and logistics constraints associated with the vast inventory of items, together with the confusion, surprises, and fog of war, disrupt and add to the unique complexity associated with the individual soldier. Nevertheless, ASB strongly endorses the system approach to managing this complex array.

ISSUE 5: Technology Assessment

FINDINGS

- **Near term opportunities exist for advances in capability (GPS, C^3, aural sensors, and protection)**
- **Insufficient coupling mechanisms (primarily a funding issue) to leverage the available Tech Base community (DARPA, NASA, DOE, industry, academia, allies)**
- **Limited external and peer review process - technology advocates dominate search for alternative solutions**
- **Many strong/effective technology elements - some are unlikely to mature in the Block I timeframe - some of only marginal value**

At the Soldier as a System Technology Area Assessment held at LABCOM, 26-27 March 1991, the following technologies were singled out as key technologies for future soldier systems: artificial intelligence; biotechnology; exoskeletal structures; light-weight portable power; modeling and simulation; neuro (behavioral) science; robotics; smart adaptive materiels; ultra small electronics and opto-electronics. It should be noted that the Panel did not carry out a detailed quantitative technology assessment since we were not briefed on all technologies and, furthermore, the Soldier System capability requirements against which to carry out such an assessment have yet to be spelled out in detail. Nevertheless, the Panel did consider technology and soldier capabilities in the context of numerous briefings it received over a six month period. A fairly detailed synopsis of our assessment of key technologies and some other elements of the technology program are to be found in Appendices E and F. In the following, we summarize our key technology assessment findings.

First, it is clear to the Panel that it is possible to build upon the existing technology base, both within and outside the Army, to considerably enhance the Soldier's capabilities in the near term. For example, the Panel believes that by exploiting state-of-the-art microelectronics, digital, sensor, and materiels technology that the soldier's capability in areas such as navigation (GPS); communications, command, and control (C3); and aural sensors and protection can be significantly enhanced. Many other opportunities to enhance the soldier's capabilities are presented and discussed in the next chart.

Second, it is the Panel's view that significant expertise relevant to the Soldier System resides outside the Army in other services (e.g., the AF integrated helmet display) and agencies such as NASA (expertise on equipment integration), DARPA, and DOE Laboratories. Other sources of relevant technologies may be found in industry, academia, and with our allies. It is the Panel's judgment that there is currently insufficient coupling (with these outside resources) to significantly leverage these other investments into the Army tech base. The Panel recognizes that establishing strong coupling is a non-trivial process and requires building a network of close professional relations and usually requires a financial commitment to invest in these outside entities.

Third, the ASB Panel perceives limited utilization of external peer review of the Soldier as a System technology base. It is the Panel's observation that the advocates of each technology dominate the search for alternative solutions. Scientists and engineers should be advocates for their technology, and the Panel applauds them for that; it is the apparent lack of checks and balances provided by peer review that is our main concern.

Fourth, it is the Panel's opinion that virtually all technologies in the Army Technology Base Master Plan could, if developed to a sufficiently mature level, significantly enhance soldier system capabilities. Obviously, though, some are likely to play a dominant role in the near term (Block I) time frame, e.g., chem/bio sensors, expert systems, light weight power for electronics, materials such as composites, and microelectronics and opto-electronics. Other technologies which, in the Panel's judgment, are unlikely to mature sufficiently soon to significantly enhance the soldier's capabilities in the near term include artificial intelligence, biomaterials, micro-climate cooling, modeling and simulation for the integrated soldier, pharmacologic aspects of neuroscience, variable complex task robotics, and biomaterials for chameleon-like camouflage. In the Panel's judgment, active exoskeletons are likely to have marginal value on the near term capabilities of the soldier.

ISSUE 5: Some Promising Technological Capabilities

Capability	SIPE ATTD
Combat Casualty Care	
Position/Navigation	•
Individual communications	•
Enhanced sensors	•
Improved Air drop	
Soldier IFF	
Chem/Bio protection	•
Individual Chem/Bio sensors	
Improved individual combat weapon	
Integrated helmet	•
Ergonomic boots	

This ASB study Panel was very impressed with the range of technology of high promise which appeared to be able to transition in the near time frame into the field in support of the soldier. It is our judgment that the capabilities of the soldier can be greatly increased and his quality of life significantly improved through the Soldier as a System Program proposed by the Army and described in this report.

We wish in this chart to communicate some of our enthusiasm for this program with a short description of a few of the technologies of high promise and of their implications to the soldier. As depicted on the chart, some of these selected promising technologies will be demonstrated in the SIPE ATTD in 1992.

- **Combat Casualty Care:** Combat casualty care represents the ultimate in the sustainment of the soldier in the field. Our Panel found the future Army soldier and his SOF counterpart will benefit greatly from information and expert systems to direct remote care, artificial blood and clotting factors, pharmaceuticals that prevent further vital organ damage from blood loss or infection, and concentrate hypertonic intravenous saline solutions to provide highly portable IV resuscitation. The combination of these medical treatment technologies is absolutely needed to offset the expected lethality of the future battlefield.

- **Position/Navigation:** Desert Storm dramatically demonstrated the utility of precision position location. Yet, we foresee even greater utilization of position/location technology as elements like GPS reception become more widely available and significantly reduced in size and cost. Programs for cost reduction and miniaturization are already underway within the Army and in cooperation with DARPA. Dismounted soldier combat effectiveness should radically increase as tactics are developed to utilize dependable and precise knowledge of where our soldiers are located and, from their reporting, where the enemy is deployed.

- **Individual Communications:** Designs to evaluate the operational utility of communication between soldiers by Low Probability of Intercept techniques will be operationally evaluated in the upcoming SIPE ATTD. We expect that the same overwhelming advantage that excellent C3I has demonstrated at the major organizational level will also be demonstrated in the operation of the small dismounted soldier unit.

- **Advanced Sensors/Integrated Helmet:** The commercial world has made tremendous progress in sensor development, both reducing costs and expanding the capability and operational utility of new sensor technologies. We believe, as do the Army technologists, that these new sensors can be packaged into an integrated helmet vision system, and that this new capability can revolutionize the ability of the dismounted soldier to locate and to successfully attack forces of considerably greater apparent strength.

- **Improved Air Drop:** New technologies arising out of advanced sensors, sport parachute development emphasis and new delivery and extraction pod techniques appear to promise the ability to satisfy the toughening safety, delivery speed, and low altitude needs of conventional contingency warfare. After periods of comparatively slow progress, we believe that this technology can move much more rapidly, that increased emphasis on air-drop technology is much warranted, and that technologies, other than parachute, should be investigated.

- **Soldier IFF:** We believe that the integrated technologies incorporated in this list will allow an interchange of precise information of friendly forces to the soldier level and, through this, an acceptable level of identification of friendly soldiers. Other interesting methods of real time identification appear plausible and entirely possible.

- **Chem/Bio Sensors and Protection:** New material technologies appear to offer far fewer operational limitations than current protective equipment. These advances coupled with new biologically based sensors offer a revolutionary change in capability and operational utility of next generation chem/bio capability.

- **Improved Individual Combat Weapon:** The applicability of inexpensive miniaturized missile seeker technology appears to make straightforward use of available infrared sight technology to permit standard rifle firing only when properly sighted on the intended target. Such a capability we feel might substantially increase the effectiveness of extended range rifle fire in combat.

- **Ergonomic Boots:** Of all the hardware of interest to the soldier, boots are probably the most important of all. Many new ideas for more effective footwear appear promising, among them contour adjustment by air inflation developed for competitive sports. We expect to see in the next few years a broadening of the operational utility of the standard issue boot.

ISSUE 5: Technology Assessment

RECOMMENDATIONS

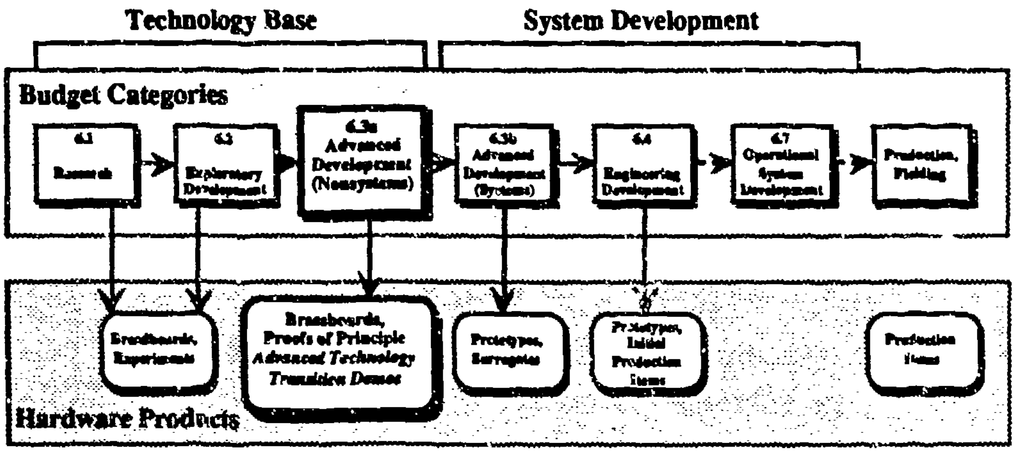
- **Capture available technologies in order to field capabilities for near-term modernization**
- **SARDA establish set-aside funding wedge to invite and incorporate technologies from external resources (approximately $10M)**
- **Establish formal interdisciplinary process to search for alternative solutions via annual external reviews of investment strategy**

The Panel's first recommendation is to capture currently available technologies to enhance the soldier's capabilities in the near term. One approach to accomplishing this task might be as follows: (1) establish capability requirements to better guide the Soldier System technology base; (2) carry out formal technology area assessments in light of the capability requirements established in (1); (3) include external peer review as part of the technology area assessment; (4) require consideration of alternative concepts early in the research and development cycle; (5) review and refine technology base investment strategy on the basis of tech base assessment in order to capture those technologies which offer significant potential to enhance a soldier's capability in the near term.

The second recommendation involves SARDA establishing a set-aside funding wedge of approximately $10M to invite and incorporate technologies from external sources. This money would be invested in other Federal agencies, industry, and academia in order to truly leverage unique technology capabilities outside the Army.

Thirdly, the Panel strongly recommends the establishment of a formal, periodic, multidisciplinary peer review process of the Soldier System tech base investment strategy, with special emphasis on consideration of alternative solutions. A key component of our recommendation is the inclusion of some reviewers external to the Army and DOD and that a variety of scientific and technical disciplines be represented on the peer review Panel.

ISSUE 6: SIPE ATTD



SIPE ATTD IS A CAPABILITY DEMO

SIPE is an Advanced Technology Transition Demonstration (ATTD) of multiple capabilities for possible inclusion in the Block I soldier as described in the Soldier Modernization Plan (SMP). Using a syst..ms approach, the SIPE program is integrating : ate-of-the-art technological capabilities into a single modular system consisting of: an advanced clothing sub-system (uniform and body armor, gloves, boots, and load bearing equipment); integrated headgear sub-systems (communications capability interfaced with weapons systems, soldier computer with expert systems, respiratory protection, laser eye protection); and micro-climate cooling powered by a Stirling engine generator or battery.

This ATTD provides an evaluation of new promising technology capabilities in an operational environment with soldiers. Its output becomes one of many other inputs to a milestone zero decision to go into development. SIPE and the future ATTD for mounted soldiers (air and ground) are major stepping stones for Soldier System improvements.

ISSUE 6: SIPE ATTD

FINDINGS

- **SIPE ATTD schedule for 1992 testing is an important step towards Soldier System Modernization, evaluating integrated, modular technology capabilities**
- **No approved exit criteria**
- **Demonstration test is not extensive enough to delineate sub-system value**
- **Program is effectively managed with realistic probability of success for several of the modular components**

In the case of the SIPE program, there are three distinct sets of criteria concerns: baseline, ATTD, and future. Baseline criteria for the individual soldier are very fuzzy and only exist on the basis of an assessment of today's performance capability. Even then it is more a specification of unit performance rather than that of an individual performer. The first set of exit criteria from the ATTD have been developed. These are largely based upon simply stating that performance must be "equal to or better than that which currently exists." Care must be taken in using such criteria as there is some doubt that many of the performance characteristics to be evaluated are themselves very well quantified. The Infantry School has also developed a set of "tentative" performance requirements for full scale development consideration. The ASB suggests that an attempt be made to identify an "in-between" set of criteria that, if achieved, would warrant an objective worthy of pursuit. This should be accomplished in consort with the user and in advance of the ATTD. Finally, the issue of the future criteria needs to be considered by TRADOC. The Air Land Battle Future does not recognize the individual soldier and therefore, it is difficult to plan a long term Soldier System program when there is no means to employ a Concept Based Requirements process, as the individual soldier requirements have never been developed. Consideration needs to be directed at soldier "skin-in" as well as soldier "skin out," e.g., heat stress, fatigue factors. Misunderstanding could undermine support for the Soldier System.

Assuming that exit criteria are developed, a modular ensemble needs to be tested in a manner to permit quantitative assessment of the relative contribution and enhancement made by each component. For example, if enhanced tactical performance is almost completely dependent on one small component, such as improved communications, in the current era of cost constraints the Block I soldier may only be able to afford this capability. The current SIPE testing program is not detailed enough to allow establishment of this type of relative sub-system valuation.

The SIPE program is close to being on schedule and is being managed well by the SIPE office which reports directly to the NRDEC Tech Director's office. The program is being accomplished through four principal contracts: (1) the integrated headgear sub-system, (2) the integrated clothing sub -system; (3) the Stirling engine generator; and (4) the overall SIPE system integrator. The Panel was convinced that integration aspects of the SIPE were under control and that the integration contractor had been provided sufficient authority to resolve interface problems. The SIPE team expressed confidence that their contractors and the Army labs providing test components for the ATTD will meet their scheduled delivery requirements. They currently do not foresee any significant technical problems in the performance of their contracts and are now receiving prototypes of the integrated headgear for early evaluation.

One technical limitation is discussed in more detail in the technology appendices. The Stirling engine required for micro-climate cooling may give off an unacceptably high acoustic or heat signature. The Panel suggests that these factors be included in the SIPE ATTD exit criteria.

ISSUE 6: SIPE ATTD

RECOMMENDATIONS

- **Establish definitive exit criteria at the modular level**
- **Test program should be designed to delineate the high payoff/low payoff technologies at modular level for a range of combat scenarios**
- **Conduct a risk analysis to identify and eliminate potential obstacles to successful ATTD test**

The Panel believes that definitive exit criteria must be established at the modular level. Furthermore, the Panel recognizes that the soldier has a large number of specific tasks. Specific exit criteria that test each modular component against the five major soldier capabilities - lethality, command and control, survivability, sustainment, and mobility-need to be established.

By closely working in this early phase with the MRDC, many soldier "skin in" problems will be eliminated before they can occur. A strong emphasis should be placed upon testing the modular approach that is being taken that will reinforce across-the-board capability potential. The fact that the complete (as best as it can now be defined) system is being considered, that it is modular, and that it is integrated, cannot be emphasized strongly enough. In order to clearly delineate which technological capability gives added value, each modular piece with its value will need to be tested in different combat scenarios against the five major soldier capabilities. For example, the Special Forces may not require chemical protection in many of their operations, and the fact that those elements of the system can be easily decoupled because of the modularity, without re-designing the system, is a positive attribute of the system approach. Other components of the Soldier System should be tested and related to the specific requirements of the various user elements of the Army. If the final Soldier System product can be "all things to all people" simply by adding or subtracting one or more of the modular sub-system components, a strong advocacy of the entire user community will evolve. In principle, the "systems" approach could be extended to all soldiers: dismounted, vehicle crews, air crews and those strictly acting in the support roles. Because of the high visibility the SIPE program enjoys, the opportunity to develop an advocacy base exists and is being exploited to some extent.

The SIPE office has reduced the technical risks, and we believe there is a high probability they (with their contractors) will deliver what has been promised for the ATTD. However, there are still a host of management, funding and analysis risks associated with the accomplishment of this program that should be explored that the SIPE office does not have the manpower to address. NRDEC should provide these resources, and not necessarily by assigning more people to the SIPE office, but by making the capability available and implementing such assessments so that all possible measures are taken to guard against the "unknown unknowns." Because of the critical importance of the success of the ATTD, every avenue should be explored to better guarantee that result.

The risks related to meeting the yet-to-be-specified ATTD exit criteria have not been identified, but as that becomes more focused, back-up approaches need to be determined along with appropriate courses of action.

Key Recommendations

Chief of Staff of the Army :	Approve Soldier Modernization Plan through Block I
Army Acquisition Executive :	Appoint a General Officer Manager to integrate the Soldier System
Assistant Secretary Army (RDA):	Establish a focal point in SARDA to manage the Soldier System Tech Base Program for the total Army
Deputy Chief of Staff for Intelligence:	Develop scenario-based threat for the future Soldier System
Commanding General, TRADOC:	Complete CBRS analyses through Soldier System level and provide a list of prioritized capability needs.

Soldiers are not managed as a system. They need to be. There needs to be a single focal point for the soldier in key places. TRADOC has a single focal point in the TRADOC System Manager. We need others. The key recommendations summarized above will allow this.

We believe that approval of the Soldier Modernization Plan through Block I is important and will send a message to the rest of the Army approving the concept of the "Soldier as a System."

Our war fighting edge is the soldier.

We must equip the soldier with the best.

Integrated, focused Soldier System management provides that opportunity.

The task ahead of all of us, "The Soldier as a System," as outlined in this report, is never as great as the power behind us. **We urge the leadership in the Army to provide that power.**

APPENDIX A

TERMS OF REFERENCE

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

29 JAN 1991

Dr. Duane A. Adams
Chair, Army Science Board
Associate Dean
School of Computer Science
Carnegie-Mellon University
Pittsburgh, Pennsylvania 15213

Dear Dr. Adams:

You are requested to appoint a panel of Army Science Board (ASB) Members to conduct a 1991 Summer Study on "The Soldier As A System." The study should address, as a minimum, the Terms of Reference (TOR) described below. The panel should consider the TOR as guidelines and may consider related issues deemed important or suggested by the Sponsor. Modifications to the TOR must be coordinated with the ASB office.

I. Background

Historically, the Army has developed and fielded soldier materiel on a piece-meal basis which has led to an ever-increasing weight burden for the soldier. The problem is exacerbated by the wide variety of soldier items, from weapons to food, and the large number of materiel developers. Soldier materiel is fielded by one or more laboratories and/or centers in each of three major commands--Army Materiel Command, Office of the Deputy Chief of Staff for Personnel, and the Medical Research and Development Command.

The soldier as a system emerged from the Soldier Integrated Protective Ensemble (SIPE) Advanced Technology Transition Demonstration, first conceived in 1988. Since that time, the Army has developed a definition for the Soldier System as part of its Soldier Modernization Plan.

a. The Soldier System consists of those items worn or consumed by the soldier and those items carried for individual use. It does not include items carried in the soldier's load which are designed to accomplish unit missions (e.g., crew-served weapons/munitions, unit radio).

b. The soldier's load includes items from the Soldier System as well as selected items of unit equipment required to accomplish the unit missions.

The purpose of this study is to explore in greater depth the logical evolution and implications of pursuing an integrated approach to development, fielding, and management of soldier related materiel.

II. Terms of Reference

a. Assess the existing Research, Development and Acquisition (RDA) process for items of materiel for the soldier and compare it to the RDA process for other types of systems. Report conclusions regarding the effectiveness of the existing process, identifying advantages and disadvantages. Recommend a best management and organizational approach for the RDA of soldier materiel. Should the soldier be managed as a major system? Particular attention should be paid to achieving integrated, coordinated, and synergistic RDA of separate items toward overall optimization of the ensemble of the soldier and his materiel.

b. Within the doctrinal context of the AirLand Battle-Future (ALB-F) concept and TRADOC-defined required battlefield capabilities, and considering the soldier as a system (i.e., as defined in the Soldier Modernization Plan) identify potential materiel and training solutions that must be developed to ensure the lethality, command and control, protection, sustainment, and mobility of the future soldier. Also assess the psychological and physiological interface of the soldier with proposed Soldier System component solutions. Address these solutions to three soldier variants: dismounted, crew mounted (air and ground), and all others.

c. For each potential materiel and training solution, assess the state-of-the-art and availability of technologies to implement it; recommend research most likely to produce required implementing technologies; and identify the time frame for implementation.

d. Rank-order each potential materiel or training solution and its implementing technology.

III. Study Support

The Military Deputy to the Assistant Secretary of the Army for Research, Development and Acquisition (LTG Cianciolo) will sponsor the study. The Cognizant Deputy will be the Deputy Assistant Secretary for Research and Technology (Mr. Singley). The DA Staff Assistants will be Sharon Vannucci, SARD-TT (lead) and MAJ Terry Rauch, SARD-TM (alternate).

IV. Schedule

The panel will begin its work immediately and conclude the effort at the 10-day summarization and report writing session to be scheduled during the end of July 1991. The exact time and location will be coordinated by the ASB. As a first step, the Panel Chairman should prepare a study plan and present that plan to the sponsor. Please provide a copy of the study plan to the ASB office.

V. Special Provisions

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

Sincerely,

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

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ON
SOLDIER AS A SYSTEM

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APPENDIX B

ISSUES RELATED TO ACQUISITION PROCESS

Discussion: Issues Related to Acquisition Process

The system for acquiring integrated "Soldier System" equipment presents a serious challenge for the current acquisition system. The ASB study panel evaluated the current acquisition process as a basis for judging whether the current system would need to be revised to meet the challenges for the provisioning of the integrated, modular and incrementally improved soldier ensemble envisioned for the future. An example presented to the ASB highlighted the long unnecessary time between development and fielding of the extreme cold weather ensemble. Several issues were identified that would require attention during the review to prepare the current system for what is projected to be needed during the transition to the integrated "Soldier System" of the future. These include the following:

- Planning, development, type classification, and acquisition processes for soldier-related equipment are fragmented and require prolonged periods of time to affect coordination by the several organizations (i.e., Army RDA, OSD, DLA) who are players at different stages in the process.

- Most items of soldier related equipment are developed and procured individually, and, therefore, each item has to move through the complex process individually.

- The recent direction by DOD to shift the preparation of the procurement technical data package and initial proof of its adequacy for manufacturing (production demonstration) to DLA further complicates this problem because it transitions responsibility for complex items from Army R&D laboratories to DLA at an awkward point in the process.

- There is currently no central plan which determines how much of what materiel would be needed to conduct operations in projected scenarios. As a result, there is difficulty matching materiel procured with the needs identified by the CINCs who have this responsibility for TO&E for their theaters.

- The DLA policy of stockage which uses "use rate" does not allow for realistic preparedness to meet a rapid deployment, especially when the number deployed (for example, during Desert Storm) is large and needs to be completed in a short period of time.

- The delays between the transfer of funds by the Army for procurement to DLA and the approval given to DLA to obligate these funds to affect procurement of the items extends the process.

- There is a hesitancy in DLA to replace an existing item already in stock with a new item which incorporates major new advances in technology, a position which prolongs the fielding process and is aggravated by poor planning.

- The basic Army RDA/DLA acquisition process is so slow that it is unable to meet the unexpected which requires a rapid response. A separate system, outside the regular Army/RDA system, had to be created to meet the CINC's requirements during the recent Desert Shield/Storm experience. The process needs attention today to increase the likelihood of having the right equipment available at the right time.

The advent of the Soldier System brings with it a concept for equipping the soldier. The soldier's equipment as an ensemble will emphasize integration to assure fit and performance of all of the elements of the assembly. The ability to change out components as the technology matures will permit gradual advancement of the capability for the soldier. The use of modularity of the assembly will permit the commander to select different combinations of the ensemble that will best meet the soldier's individual mission needs.

We accept the premise that rapid, massive deployment, as seen during the recent Desert Shield/Storm or small highly mobile forces deployed to future trouble spots as needed are harbingers of the future. The acquisition process for tomorrow for Soldier System equipment will require major streamlining and flexibility to be able to meet both the long-term planned acquisition of the changing ensemble and the ability to surge to meet the unplanned or contingency operations. Central planning for fielding of Soldier System Materiel appears mandatory to achieve this end.

APPENDIX C

SOLDIER ENHANCEMENT/FIELD ASSISTANCE IN SCIENCE AND TECHNOLOGY

Soldier Enhancement/Field Assistance in Science and Technology

In response to the recognition that the current acquisition process is unable to respond to meeting the unexpected, contingency, and acute needs of the CINCs, the Army has established two programs which have been quite successful. They are the Soldier Enhancement Program (SEP) and the Field Assistance in Science and Technology (FAST) program.

In the case of SEP, the Congress has been most generous in providing funding for the last two years to answer the field needs for correcting deficiencies in the equipment of the soldier. More importantly, the products gained from this program during these two years have exceeded the expectations. As a result of the success of SEP to date, both Congress and the Army are proposing to fund the effort for the FY 92. In recognition that the program is filling a gap in the ability of the acquisition process to meet immediate and/or unexpected needs, the program recently has been brought under the oversight of the TSM-Soldier along with the other soldier-related CBRS efforts.

Its modus operandi is one of allowing the need, once defined, to be directly and promptly addressed through a coordinated effort by the SEP office. The SEP project officer can use any avenue, the RDA laboratories or nondevelopment items (NDI) sources, for gaining the solution to problems. The flexibility inherent in the current program has been key to its success. This must be maintained in whatever configuration it takes if the degree of success is to be continued.

A review of the expenditures of funds during FY 91 includes commitments of $8.9M for supporting needs in weapons and munitions, $.85M for efforts in communications, $1.7M for combat clothing and individual equipment, and $2.3M for the area of food, water, and shelter. The latter two categories reflect direct support of areas that would fall within the current definition of the Soldier System. Further analysis of the expenditures for FY91 reveals that while the products being procured are judged quite useful and needed, it is surprising to see this pathway being used to fund what were otherwise unfunded 6.3B and 6.4 projects. It raises the question as to whether this dilutes the capability and intent of this program. It is recommended that the Army examine the strategy to be followed in this program for the future to insure that it does not get divorced from its original intent which is what has made it so successful over the past two years.

The FAST program was established as a means of providing for the CINCs' direct access to the technology base that rests primarily in the AMC laboratories and centers and a means of getting the CINCs' concerns addressed. At the same time, by having a representative from the RDA community in residence on a CINC's staff, a good conduit is provided for keeping the technology organizations informed on the concerns and problems being encountered in the field. This program is judged by both the field and the laboratories as a resounding success. It strongly testifies to the importance of near real-time communications at both ends of the process. This and other innovative ideas for enhancing communications and problem solving will be needed to make the Army RDA/DLA process more responsive to meet the needs of the Soldier System.

APPENDIX D

LIST OF CLOTHING AND INDIVIDUAL EQUIPMENT ITEMS

ITEMS	DTSS	AVN	CREW CVC	OTHER SOLD	NON-TAC	CURRENT RESPON
R&D/OMA:						
Improved SWD Goggles	X		X			PM-CIE
Eye Armor	X	X	X	X		PM-CIE
Spec Prot Eyewear(Cyl)	X		X			PM-CIE
Laser Eye Protection	X		X			PM-CIE
AUIB P3I Outergarment		X				PM-CIE
Aircrew BDU		X				PM-CIE
Aircrew Cold Wea Cloth Sys		X				PM-CIE
Combat Boot Heel	X		X			PM-CIE
Fur Ruff	X		X			PM-CIE
ECWCS Repair Kit	X		X			PM-CIE
Mattox	X		X			PM-CIE
Tap Suit Material				X	X	PM-CIE
Lightweight Flashlight	X		X			PM-CIE
Ltwt Extra Weather Shelter	X		X			PM-CIE
Desert Battledress Uniform	X		X			PM-CIE
Hot Weather BDU	X		X			PM-CIE
Improved Pasgt Helmet	X		X			PM-CIE
Stepo I				X	X	PM-CIE
Soldier Ground Insulator	X		X			PM-CIE
Multiple Threat Body Armor	X		X			PM-CIE
Ground/Air MCC		X	X	X	X	PM-CIE
Sarvip		X				PM-CIE
Mask Drinking Sys Int.	X		X			PM-CIE
Mask Drinking Sys	X		X			PM-CIE
Countermine Body Armor	X			X		PM-CIE
Green Vinyl Overshoe	X		X			PM-CIE
Overwhites	X		X			PM-CIE
Physical Fitness Uniform					X	PM-CIE
Military Motorcycle Helmet	X			X		PM-CIE
Accelerated BDO	X		X			PM-CIE
Imp Desert Combat Boot	X		X	X		PM-CIE
Project Officers' Handbook					X	PM-CIE
Stepo				X	X	PM-CIE
AUIB P3I Packaging		X				PM-CIE
AUIB P3I CB Undergarment		X				PM-CIE
Special Purpose Tap Hood				X	X	PM-CIE
Foreign Ltwt Suit Eval	X			X		PM-CIE
Ltwt CB Prot Garment	X	X	X			PM-CIE
Laser/Ball Toric Eye (P3I)	X		X			PM-CIE
Combat Footwear Desert	X		X			PM-CIE
Combat Sol Sleeping Bag	X					PM-CIE
Inter Cold Wea Boot	X					PM-CIE
Avia Aux Lighting Device		X				PM-CIE
Interim Inter CW Glove	X					PM-CIE
Artillery Caps				X		PM-CIE
Ghillie Suit Accessory Kit	X					PM-CIE
Pasgt Suspension	X	X				PM-CIE

ITEMS	DTSS	AVN	CREW CVC	OTHER SOLD	NON-TAC	CURRENT RESPON
R&D/OMA:						
Cold Regions Camouflage	X	X				PM-CIE
ECWS Repair Kit	X	X				PM-CIE
Duffel Bag					X	PM-CIE
Military Beret					X	PM-CIE
Wet Wea Parka/Trousers	X	X				PM-CIE
Women's Shirt					X	PM-CIE
M4 Carbine	X					AMCCOM
M16A2 Optics(M16A3)	X					AMCCOM
M249 Optics (M249A1)	X					AMCCOM
M249 Assault Pack	X					AMCCOM
M16A2 Grenade	X					AMCCOM
PERSONAL WEAPONS:						
M16A1/A2	X	X	X	X		AMCCOM
M249, SAW/M60	X	X	X	X		AMCCOM
M203 Grenade Launcher	X	X	X	X		AMCCOM
Carbine		X	X	X		AMCCOM
Basic Load M16A2	X	X	X	X		AMCCOM
Cleaning Kit, Weap, 5.56	X	X	X	X		AMCCOM
Bayonet	X	X	X	X		AMCCOM
Pistol 9MM	X	X	X	X		PEO-ARM
Grenade Hand Fragmentation	X	X	X	X		AMCCOM
Shotguns				X		AMCCOM
C3I:						
Antenna, AT-984\C	X					PEO-COM
PRC-77 w/Acess Pack	X					PEO-COM
GPS	X					PEO-COM
NBC:						
Mask, Prot M17/17A2/40	X					AFP
Decon Kit	X					AFP
MEDICAL:						
First Aid Pouch	X	X	X	X		OTSG
Ear Plugs	X	X	X	X		OTSG
RATIONS:						
Canteen w/Cup & Cover	X	X	X	X		PO-AFFS
Canteen 2 Qt	X	X	X	X		PO-AFFS
MRE	X	X	X	X		PO-AFFS

ITEMS	DTSS	AVN	CREW CVC	OTHER SOLD	NON-TAC	CURRENT RESPON
LLRP	X	X	X	X		PO-AFFS
Ration Cold Weather	X	X	X	X		PO-AFFS
Fork, Field Mess	X	X	X	X		PO-AFFS
Knife, Field Mess	X	X	X	X		PO-AFFS
Spoon, Field Mess	X	X	X	X		PO-AFFS
Pan, Field Mess Kit	X	X	X	X		PO-AFFS
OTHER CIE:						
E-Tool	X	X	X	X		PM-CIE
Flashlight	X	X	X	X		NONE
Battery 5590 (Lithium)	X	X	X	X		EDTL
Battery 5598	X	X	X	X		EDTL
Alice Frame	X	X	X	X		PM-CIE
Bag, Waterproof	X	X	X	X		PM-CIE
Toilet Articles	X	X	X	X		PM-CIE
Alice Pack	X	X	X	X		PM-CIE
Field Pack Lg Internal F	X	X	X	X		PM-CIE
Ammo Pouch	X	X	X	X		PM-CIE
Bag, Barracks	X	X	X	X		PM-CIE
Bag, Waterproof, Clothing	X	X	X	X		PM-CIE
Goggles, Dust and Sun	X	X	X	X		PM-CIE
Goggles, Laser Safety	X	X	X	X		PM-CIE
Mask Carrier	X	X	X	X		PM-CIE
Mat, Sleeping	X	X	X	X		PM-CIE
Shelter, Half	X	X	X	X		PM-CIE
Sleeping Bag	X	X	X	X		PM-CIE
Brown Bath Towel	X	X	X	X		PM-CIE
Alice Pack Desert Cover	X	X	X	X		PM-CIE
Holster/Shoulder w/Lanyard	X					PM-CIE
Holster, Hip	X					PM-CIE
CLOTHING:						
BDU, Lightweight	X	X	X	X		PM-CIE
BDU, Desert	X	X	X	X		PM-CIE
BDU, Temperate	X	X	X	X		PM-CIE
Helmet, Kevlar	X	X	X	X		PM-CIE
Sock Cushion, Sole	X	X	X	X		PM-CIE
Lt Duty Gloves w/Inserts	X	X	X	X		PM-CIE
Underwear Kit(Shirt/Draw)	X	X	X	X		PM-CIE
Underwear Kit Brown	X	X	X	X		PM-CIE
Socks	X	X	X	X		PM-CIE
Liner, Poncho	X	X	X	X		PM-CIE
Poncho	X	X	X	X		PM-CIE
Parka, Wet Weather	X	X	X	X		PM-CIE
Field Jacket Liner	X	X	X	X		PM-CIE
Field Jacket	X	X	X	X		PM-CIE

ITEMS	DTSS	AVN	CREW CVC	OTHER SOLD	NON-TAC	CURRENT RESPON
Field Jacket Desert	X	X	X	X		PM-CIE
Belt Black Web W/Buckle	X	X	X	X		PM-CIE
Boots, Hot Weather	X	X	X	X		PM-CIE
Boots, Inter Cold Weather	X	X	X	X		PM-CIE
Boots, Vapor	X	X	X	X		PM-CIE
Boots, Chemical	X	X	X	X		PM-CIE
Chemical Overgarment	X	X	X	X		PM-CIE
Cover, Helmet	X	X	X	X		PM-CIE
Hood, Extreme Cold Wea	X	X	X	X		PM-CIE
Desert Hats	X	X	X	X		PM-CIE
Pistol Belt	X	X	X	X		PM-CIE
Liner, Cold Wea Coat	X	X	X	X		PM-CIE
Liner, Cold Wea Trouser	X	X	X	X		PM-CIE
Extreme Cold Wea Cloth.	X	X	X	X		PM-CIE
Liner, Helmet, Grnd Troop	X	X	X	X		PM-CIE
Trigger Finger Mittens	X	X	X	X		PM-CIE
Trigger Finger Shell	X	X	X	X		PM-CIE
Trigger Finger Inserts	X	X	X	X		PM-CIE
Mitten Inserts, Cold Wea	X	X	X	X		PM-CIE
Mitten Shells, Cold Wea	X	X	X	X		PM-CIE
Overshoes, Boot	X	X	X	X		PM-CIE
Helmet Liner Insulator	X	X	X	X		PM-CIE
Scarf, Wool	X	X	X	X		PM-CIE
Socks Wool	X	X	X	X		PM-CIE
Suspenders, Ind Equip	X	X	X	X		PM-CIE
Suspenders, Trousers	X	X	X	X		PM-CIE
Sweater Cold Weather	X	X	X	X		PM-CIE
Trousers Wet Weather	X	X	X	X		PM-CIE
Underwear/Wool/Ctn Btms	X	X	X	X		PM-CIE
Underwear/Wool/Ctn Tops	X	X	X	X		PM-CIE
BDU, Cap	X	X	X	X		PM-CIE
Pasgt Vest	X	X	X	X		PM-CIE
Pasgt Vest, Desert Cover	X	X	X	X		PM-CIE
Boot, Cbt, Leather	X	X	X	X		PM-CIE
Ind TAC Load Bearing Vest	X	X	X	X		PM-CIE
Belt, Pistol W/suspenders	X	X	X	X		PM-CIE
Ext Cold Wea Sleep Sys	X	X	X	X		PM-CIE
Sleep Shirt	X		X	X		PM-CIE
CVC:						
Coveralls, NOMEX			X			PM-CIE
Coveralls, Summer			X			PM-CIE
Coveralls, Winter			X			PM-CIE
Gloves, CVC Summer			X			PM-CIE
Gloves, CVC, Cold Wea			X			PM-CIE
Gloves, Inserts, Cold Wea			X			PM-CIE
Body Armor/CVC/Frag Prot			X			PM-CIE
Mask/Face/CV/Flame/Dust/Wind/Fr			X			PM-CIE
Flight Bag, Helmet			X			PM-CIE

ITEMS	DTSS	AVN	CREW CVC	OTHER SOLD	NON-TAC	CURRENT RESPON
Helmet, CVC			X			PM-CIE
Vest, Micro-Climate Cooling			X			PM-CIE
Mask CB Prot M24/42			X			AFP
AIRCREW:						
Undershirt, Cold Wea		X				PM-CIE
Drawers, Cold Wea		X				PM-CIE
Liner, Coverall AC		X				PM-CIE
Coverall, AC		X				PM-CIE
Overall, Bib		X				PM-CIE
Jacket, AC Cold Wea		X				PM-CIE
Balaclava, AC		X				PM-CIE
AC Battledress Uniform		X				PM-CIE
Coveralls, Flyers, Summer		X				PM-CIE
Jacket, Flyers Ltwt		X				PM-CIE
Gloves, Flyers, Summer		X				PM-CIE
CB Prot Mask M25/43		X				AFP
Helmet SPH-4/AH-64		X				PM-APACHE
Helmet HGU-56/P		X				PM-ALSE
Boots, Flyer, Cold Wea		X				PM-CIE
Hood, Jacket, AC Cold Wea		X				PM-CIE
AUIB		X				PM-CIE
Boots, Chem Prot		X				PM-CIE
Gloves, Chem Prot		X				PM-CIE
Vest, Survival		X				PM-CIE
Body Armor AC, Front		X				PM-CIE
Body Armor AC, Back		X				PM-CIE
Harness, Parachute, Fitted		X				TROSCOM
Harness, Parachute, Chest		X				TROSCOM
Harness, Parachute, Gunners		X				TROSCOM
Parachute Back Type		X				TROSCOM
Glasses, Aviator		X				PM-CIE
Life Preserver, Underarm		X				AF
Life Raft, AC		X				PM-ALSE
Vest, Micro-Climate Cooling		X				PM-CIE
Oxygen Mask		X				AF
Night Vision Goggles		X				PM-NVD
Laser Visor SPH4		X				PM-CIE
Boots, Flyer, Leather		X				PM-CIE
Helmet Bag, Flyers		X				PM-CIE
Kit Bag, Flyers		X				PM-ALSE
Survival Kit, Hot Cold or Overwear		X				PM-ALSE
DRESS/SPECIAL PURPOSE:						
Service Green Uniform Coat					X	PM-CIE
Service Green Uniform Trousers					X	PM-CIE

ITEMS	DTSS	AVN	CREW CYC	OTHER SOLD	NON-TAC	CURRENT RESPON
Woman's Green Slacks					X	PM-CIE
Woman's Green Skirt					X	PM-CIE
Army Green Shirt					X	PM-CIE
Opt Sht Sleeve Shirt Gr Shirt					X	PM-CIE
Women's Green Shirt					X	PM-CIE
Women's Oxford Shirt					X	PM-CIE
Gabardine Svs Uniform					X	PM-CIE
All-Weather Coat					X	PM-CIE
Windbreaker					X	PM-CIE
Garrison Caps					X	PM-CIE
Brass Belt Buckle					X	PM-CIE
Black Leather Dress Gloves					X	PM-CIE
Black Socks					X	PM-CIE
Black Shoes					X	PM-CIE
Pumps					X	PM-CIE
Handbag					X	PM-CIE
Universal Neck Tab					X	PM-CIE
Necktie					X	PM-CIE
Dress/Mess Uniforms					X	PM-CIE
EOD Suit					X	PM-CIE

APPENDIX E

ASB ASSESSMENT OF FUTURE SOLDIER SYSTEM EMERGING TECHNOLOGIES

ASB Assessment of Future Soldier System Emerging Technologies

Numerous potential opportunities for soldier performance enhancement are presented by existing and foreseeable technology. Not all of these are equally likely to be successful nor do they have equal potential value. Therefore, in the face of limited resources it is necessary to carefully assess the likely value and likely availability of the various possibilities and consider possible alternatives in order to maximize the use of available resources. At the Soldier as a System Technology Area Assessment held at LABCOM, 26-27 March 1991, the following were identified as key technologies for future systems:

- biotechnology
- artificial intelligence
- exoskeletal structures
- modeling and simulation
- neuro (behavioral) science
- light-weight portable power
- robotics
- smart adaptive materiels
- ultra-small electronics

The ASB panel did not carry out a detailed quantitative technology assessment on all of these technologies. Further, the Soldier System requirements against which to carry out an assessment have yet to be spelled out in detail, and, therefore, the panel's subjective judgment was used to assess utility. Nevertheless, the ASB summer study panel did discuss these nine key technology areas over a six month period in enough detail to form many conclusions, and our comments serve to highlight both possibilities and potential limitations. The collective judgments of the panel are summarized on the following chart and are discussed in subsequent paragraphs.

ASB Assessment of Future Soldier System Emerging Technology

Emerging Technology	Near Term Block I Prob. of Success/Value	Future Block II (if funded) Prob. of Success/Value	Comments
Biotechnology			
– Chem/bio sens	H/H	H/H	Near term
– Biomaterials	L/M	M/H	High current cost of goods
– Pharmaceutical	L/H	M/H	Long lead times
Artificial Intelligence			
– Decision making	L/M	M/M	Nascent technology
– Expert system	H/H	H/H	Available now
Exoskeleton			
– Passive/airdrop	H/H	H/H	Stress distributor
– Powered	L/L	L/L	Variable task robotics require development of many nascent technologies
Light weight power			
– Electronics equip.	H/H	H/H	Commercial batteries available
– Microclimate	L/L	L/L	Increased weight & signatures/Consider alternatives/Physical chemistry & thermo-dynamic limits
Modeling & Simulation			
– Component level	H/M	H/H	Evaluation and training tool
– Integrated Soldier	L/H	M/H	Complexity/realism crucial
Behavior Neuroscience			
– Psychology	M/L	M/L	Mature technology
– Pharmacologic	L/M	L/M	Nascent technology/incremental improvements feasible
Robotics			
– Single task	H/L	H/L	Difficult in tactical environment at soldier level
– Variable task	L/H	L/H	Nascent technology
Advanced Materials			
– Composites	H/H	H/H	Available now for light weight materials
– Low signature	M/H	M/H	Moderate gains feasible
– Chameleon	L/L	L/L	May increase signature in some areas/highcost
Ultra Small Electronics			
– C^3 equip.	H/H	H/H	Commercial technology available, emphasize
– Electro-optics	H/H	H/H	Applications
– Soldier computer	H/H	H/H	Expert systems

Key: L = Low, M = Medium, H = High

Biotechnology.

In identifying Biotechnology as key for soldier systems, the Army astutely recognized the potential for major improvements in sustainment, performance and protection from these technologies. Biotechnology historically refers to the production of gene products - proteins - in cells not naturally endowed with the gene. Biotechnology has generically become to mean any application of this or related technologies. Potential applications of soldier system interest include: sensors and other identification technology, medical applications, chemical protection, and novel materials.

Biotechnology offers dramatic advances in sensor and identification technology. The need for development of specific sensor for chemical or biological threats "high tech canaries" is obvious when the performance degradation of wearing MOPP 4 suits unnecessarily is considered. By identification of specific enzymes or monoclonal antibodies, the rapid identification of very low level threats can be achieved. Biological threats could only be detected by biosensors. Each threat would require a specific test, but the weakness of this technology is the inability to identify a novel agent. Thus, accurate threat assessments are essential. Small molecule threats such as a phosgene would not be detected by biosensors. A broad based program would also require development of chemical sensors such as mass spectrometry or wet matrix chemistry to detect some chemical threats. Initial versions of NBC detection equipment may be too bulky for individual soldier use. Other identification solutions offered by biotechnology include the polymer chain reaction to magnify trace amounts of DNA. This technique may be useful in graves registration units, or military police applications. In the identification and sensor areas, the Army Chemical Research Development and Engineering Center is utilizing biotechnology, and the short and long term promise is high. Considering the wide range of possible threats, a broad biotechnology based identification capability will probably not be achieved in the short term, but limited warning systems may become available.

The medical applications of biotechnology are proven including applications in diagnostic testing, vaccines, wound healing, and combat casualty care. Biotechnologies most wide-spread application in the civilian field has been in medical diagnostics, not pharmaceuticals. The most obvious example is the introduction of the HIV (AIDS) test; in both civilian and military areas the HIV blood test has allowed elucidation of the natural history of HIV disease, determined the size of the potential threat, and allowed targeting of preventative education programs. The Army's program is considered the world's finest. To a lessor degree other diagnostic tests based on biotechnology are improving medical care by providing physicians accurate, cost effective information. The Army has in the past leveraged well the civilian diagnostic technology for military applications. No broad Army research project in this area is ongoing - this approach is sensible as the technology is well enough developed to require mostly application testing rather than basic research. Any specific need could be quickly met and implemented.

Vaccines are the most cost effective means of minimizing the impact of medically related casualties. Review of past wars' casualty statistics reveals that infectious diseases are often the leading cause of casualties and lost duty time. Since the Army may have to fight in a as with infectious diseases uncommon in CONUS, vaccine development has been a long term Army priority. Classic vaccine technology - attenuated live virus or killed virus preparation - have inherent limitations: the former by viruses that may be too virulent to be attenuated (e.g., HIV-AIDS virus), the latter by killing methods that destroy or alter the three dimensional structure required for effective immune protection. Biotechnology, by using only one part of a virus or other infectious agent, can exactly duplicate the natural structure without any risk of infection. The current Army efforts in the vaccine area emphasize (except for the special case of AIDS) infectious diseases not of commercial interest in the United States and are well directed. The Army AIDS vaccine program is a world leader and is cooperating with many universities and pharmaceutical companies. The Army has a unique HIV infected population - the only population in which the time they became infected is known, because of the random HIV screening program. The Army has pioneered the concept of a vaccine as a potential treatment modality. Likewise, the Army overseas laboratories have been instrumental in determining the number of strains of the AIDS virus that will determine the mix of required vaccines. The ASB is impressed by the vaccine program and believes it is currently appropriately funded. However, the long lead times required to test and obtain FDA approval for vaccines will delay widespread availability of new vaccines until at least the year 2000.

Slow wound healing has been a long term problem for centuries. Large open wounds often become infected, complicating care and delaying recovery. Healing rates are in general age dependent; for instance, fetuses and new bones often heal at amazing rates. Biotechnology has allowed the growth factors to be identified, their genes cloned and subsequently inserted into cells that lead to large scale production. Currently in preclinical and clinical testing in the civilian field are growth factors that dramatically heal open wounds remarkably by decreasing healing times, and improve outcomes of bone fractures. In addition, bone growth factors may eliminate the need for bone grafting in many restorative procedures. Since the basic technology is developed, the Army should focus testing growth agents in injuries that occur in the military arena - the civilian programs are focused primarily in improved wound care in elderly patients. The Army-stated goal of 20% improvement in return-to-duty rates in this area may likely be far exceeded. Since the therapeutic effects will be obvious in short timeframes, these agents may be available by 1997.

Biotechnology offers unique potential for improvement in combat casualty care. The applications of many diverse technologies in combat casualty care is discussed at the end of this appendix. Blood substitutes are now in extensive preclinical testing. In addition the development of recombinant derived clotting factors will reduce the need for fresh whole blood which remains to date the best blood therapy for severely injured traumatic casualties. The Army has astutely identified the emerging field of vital organ protection following trauma. The human response to massive injury is often inappropriate causing greater and potentially fatal injuries to vital organs such as the lung, liver, and brain. Specific blockers of white blood cell migration have been shown to be dramatic in protecting vital organ after hemorrhagic shock (blood loss) in primate models. Likewise agents that protect against the systemic effects of wound infections have also been shown to be effective in animal models. Another area that also interfaces with growth factors and novel biomaterials is burn care - improvements in this area will require application of all facets of biotechnology. The current Army program is appropriate for the stage of development these drugs are in. However, as recognized by MG Travis, CG, US Army Medical Research and Development Command, as human trials appropriate for military applications are started. increased funding for development in this area may be needed. The panel agrees with his approach; our expectation is that increased availability of pharmaceuticals for testing will occur over the near term during the next five years.

Biotechnology offers at least two approaches to chemical protection, pharmaceutical and enzymatic. Since most nerve agents react to one specific neuroreceptor, the creation of a false receptor that could safely flood a soldier's blood stream may provide an effective safe prophylactic therapy. Humanized monoclonal antibodies offer this approach; the efforts in this area are encouraged by the panel. Although civilian application of this technology is not immediately obvious, an agent as described above could potentially treat myasthenia gravis and pesticide poisoning. Biotechnology can produce enzymes - proteins that chemically convert one substance to another. Therefore, if enzymes are identified from any source - plants, bacteria, or animals - that degrade a chemical agent, the enzyme could be made in large quantities then potentially incorporated into a fiber matrix. The panel believes that this product, dubbed "reactive fibers" are a potential fabric in future NBC gear and support this technology initiative. The choice of which enzyme to use will depend on accurate threat analysis. The timeframe for development may be long, and this technology may not be mature enough for use in the next generation of protective gear. Civilian development is unlikely - applications would be limited to hazardous material handling.

Biotechnology offers many innovative approaches to material technology. The current program in spider silk will most likely meet the goal of providing increased fiber break strength. Applications include ballistic protection or lighter weight equipment. The subsequent application of this discovery is problematic. The current cost of goods for biotechnology products is very high; therefore, the use of spider silk technology with current biotechnology production capabilities is not economically feasible. This should not discourage further research in this area. For instance, if the tertiary structure of spider silk is elucidated, manmade fibers may be able to mimic their strength. This is not a farfetched concept. Recently the Army started evaluating new ceramic ballistic protection based on the structure of crystal in abalone shells. The abalone's extremely impact resistant shell has the same chemical, calcium carbonate, as common chalk, but a unique structure. Another approach is to insert spider silk genes in plants. Recently, a potential large scale production of human blood product was demonstrated in a tobacco plant. Biomateriels have great long term promise; however, it is unlikely they will be used in the near term. Likewise, the Army initiative to develop biopolymers for packaging materiels is well directed as research will likely meet the goal of longer shelf-life of rations. The production problems of making polymers of complex sugars are more straightforward than mass production of complex proteins.

In conclusion, the biotechnology area represents a multi-faceted key future in Army technology that deserves continued tech base support. Only some payoffs will be short term, but the long term potential of all areas is high to ultimately improve individual soldier performance, protection, and sustainment.

Artificial Intelligence.

The panel recognizes that Artificial Intelligence (AI) offers great potential with respect to decision making on the battlefield; at the unit level and higher; and in large weapons platforms, such as tanks and helicopters. With respect to the soldier, however, the panel believes that utilizing this technology at the individual soldier level may take longer to mature. As the technology matures it may well become available at the individual soldier level and thus enhance his or her capabilities. The panel is much more optimistic with regard to expert systems for the soldier, in that near-term availability is high and the value of the added capability to the soldier is high. Specifically, we anticipate the utilization of expert systems to considerably enhance a soldier's capabilities in areas such as battlefield combat care, and repair and maintenance of individual equipment. The availability of soldier expert systems will also obviously impact the way the future soldier is trained. Finally, we note that the application of expert system technology to the soldier, is closely coupled and dependent upon other technologies supporting the development of the soldier's computer. The panel did not find as many and as broad programs in AI and expert systems as their potential merits.

Exoskeleton

Three classes of exoskeletal aids to soldier performance were discussed: orthopedic braces to redistribute the stresses of parachute landings to reduce injury; passive load bearing forms to most favorably distribute the load of equipment carried; and, finally, active, powered complete or partial exoskeletons for strength and speed enhancement.

This panel believes braces to redistribute stresses due to parachute landings have considerable merit. Their development represents an extension of concepts already widely used in sports equipment, such as modern ski boots which reduce ankle injuries and football leg and arm supports.

However, we did not sense adequate attention was being placed in this area. Some braces accomplish their purposes by redistributing the forces to heavier bones or wider areas so that local stresses are reduced. Care must be taken in the design such that stresses at the point of force application to the human body are actually reduced by spreading the forces over wide areas or to larger bones of strong structures. We believe that externally applied (velcro wrapped) foot, ankle, knee, and perhaps back and neck braces would reduce airdrop injuries to a large percentage. Passive load bearing frames or back packs are similar braces in that they redistribute forces with the intent of reducing local stresses. In both the near and far term the availability is high and the technology is mature, but the opportunities for enhanced value or significant performance enhancement are quite limited. The panel, however, strongly encourages consideration of alternative methods for transport of soldier equipment.

A powered, active exoskeleton might, in theory, provide significantly enhanced strength, speed and endurance. The question is whether, and if so how soon, the requisite technologies could be developed and how broadly applicable special purpose exoskeletons would be throughout the Army force structure. There are four central problems yet to be solved, including; power, control, cost, and other operational limitations.

At rest, a human generates a couple of hundred watts of power due to metabolism. In motion or action, obviously, he must generate several kilowatts. To improve on human performance, therefore, an exoskeletal power source must be capable of supplying many kilowatts. To provide this in a man-made exoskeleton portable package is a significant challenge for which there is no immediately apparent solution. The closest is a small gasoline powered engine-generator. Even if such were immediately available, the acoustic and infrared signatures would be so great as to require significant additional development. This may not be a problem for the crew and support soldiers.

Even more serious is the problem of control. The signals used by a human in controlling his limbs are more complex than commonly realized. One integrates kinesthetic senses, sense of muscle contracting, sense of joint position, visual cues, balance cues and possibly others. Those working with exoskeletons are far from that degree of sophistication in sensing and integration of the sensed information. Another difficulty is that the materials available do not come close to the structural and actuator capabilities of human bone and muscle. The cost of supplying exoskeletal assistance to soldiers in the field may be prohibitive, especially until major advances are made in the sensors and miniature actuators that are required.

Finally, flexibility and adaptability are central features of human soldiers on the battlefield. In order to utilize an exoskeleton some unknown fractions of flexibility and adaptability must be sacrificed, e.g., could one swim or wade, or climb a tree or a steep irregular slope in an exoskeleton? In addition, there is the question of reliability and failure modes, i.e., gradual versus catastrophic.

Due to these factors, while the potential value or performance enhancement may, in theory, be high, the likelihood of a practical exoskeleton becoming available during either the near or long term is judged to be low.

Lightweight Portable Electrical Power

In order for the future soldier to take advantage of advances in other technology areas such as microelectronics, computers, sensors (visible, infrared, acoustic), communications and so on, it is essential that efficient, lightweight, easily portable sources of electric power be provided. Such power might be provided by batteries, fuel cells, and engines.

With respect to meeting the near term and long term needs to power future soldiers' electronics, the panel believes that evolving battery technology will be sufficiently available to meet these needs as they evolve. This will lead to enhanced soldier capabilities, since it will permit the soldier to utilize advances in the other technologies previously mentioned. We agree with the need to aggressively seek ways to increase energy storage per unit cost and per unit weight by being alert to alternative approaches being developed in the commercial sector.

Since the power requirements for micro-climate conditioning and for exoskeleton aids each are estimated to be at least three times greater than that required for soldier electronics, the use of batteries alone for these tasks for extended periods is probably not feasible, necessitating the development of alternative approaches to energy storage and energy generation technologies, which in turn are dependent on multiple evolving technologies. For this reason the panel's judgment is that the availability of individual portable power sources for micro-climate conditioning is low in the near and far term. Of particular concern to the panel is the possibility of engine-type sources of power considerably enhancing the soldier's infrared and acoustic signatures. This latter consideration emphasizes the need for chemical protection systems able to "open" to the atmosphere in non-chemical environments and to be non-power consuming in that situation.

In summary, the panel believes the supplying of portable, lightweight, "low-signature" sources of power to be a critical technology issue for the future soldier in many, if not most cases. However, for micro-climate cooling, some additional power will be required. The most promising alternative to many of the panel was seen to be individual soldier carried batteries with recharging capability from a common squad level silent motor generator.

Modeling and Simulation.

The subject of modeling and simulation has been extensively addressed by the other 1991 ASB summer study entitled "Army Simulation Strategy." The results of that study cover many aspects of modeling and simulation with emphasis on development, testing, and training. Of particular relevance to the Soldier as a System is the panel's finding that the "Electronic Battlefield" will revolutionize training, a most important element in enhancing the performance of a soldier as a system, and the integration of several individual Soldier Systems into larger systems at the squad, company, etc. level.

The Soldier as a System panel also believes that technologies such as computer-aided design (CAD) can be profitably applied to the development and testing of the individual Soldier System in order to assure both performance and compatibility (in advance) of all the subsystems making up the Soldier as a System.

In summary, we urge the Army to not only make use of advances in modeling and simulation in connection with the "electronic battlefield" but to also make use of this technology in designing and integrating the Soldier System of the future.

Neuroscience (Behavior) Technology.

Neuroscience is another identified key technology for the soldier system. However, unlike biotechnology, the current effort is focused in only a few areas: psychiatric support; medical countermeasures to performance degrading effects of battlefield threats; amelioration of neurological side effects of drugs; neural receptors; performance enhancing rations, and improved understanding of human cognitive factors that determine target recognition. An area not being aggressively investigated is pharmacologic performance enhancement. In the following review, the panel notes their agreement with the current tech base investigative strategy and investment.

The panel agrees that the approaches for the prevention and care of combat psychiatric casualties needs improvement. Furthermore, the optimum therapeutic approach to battlefield stress needs to be determined. Cold, altitude, jet lag and sleep loss are becoming more common with rapid deployment and night fighting capabilities. Field counter measures that both prevent environmental casualties and ameliorate mental and physiological performance degrading effects of climate stress would be ideal. The current plan to develop a prototype laboratory system that can test both nonmedical and medical therapies is a good first step. The time frame for improvements depend on the intervention. Behavior approaches would be easier to implement compared to pharmaceutical approaches. Central nervous system side effects currently limit the use and effectiveness of many pharmaceutical agents. The performance degradation of side effects of current and future chemical warfare pretreatment need to be fully evaluated. The use of Halcion to treat jet lag is common among civilians; however, the occurrence of transient amnesia makes this and similar agents dangerous in the tactical situation. The current research program is appropriate in this area, but payoffs will be in the medium to long term.

An overlap area of neurosciences and biotechnology is the elucidation of the neuroreceptors that are targeted by nerve agents. As described in detail in the biotechnology section, this work may lead to the development of false receptors that bind and prevent nerve agent action. Likewise, the receptor could also be used as a biosensor. The panel supports this research initiative and believes that benefits may be available in both short and long term.

Performance enhancement has a long checkered history. A century ago cocaine was introduced; fifty years ago, amphetamines; both of these drugs represent major societal problems. Although the ASB detected enthusiasm for a pharmaceutical enhancer among tactical forces, we agree that this should not be a research priority. The informed consent issue alone would make testing and field use problematic. The potential consequences of introducing another potentially abused substance far outweigh any benefits. The panel agrees that the current approach of tailoring the nutrient contents of rations to enhance performance is a safer approach. However, the stated goals of twenty-five percent enhancement of performance should be restated to focus on prevention of performance degradation. Anecdotal, not confirmed information from Operations Desert Shield/Storm presented to the Science Board suggested that the current MRE rations were not consumed in adequate quantities to prevent excessive daily weight loss. The desirable short term goal of field ration program may be just to preserve predeployment performance levels of soldiers in the field, especially under stresses of sustained operations at environmental extremes.

The final area of neurosciences is the further understanding of the human cognitive progress in order to design better equipment particularly in target recognition. This not only improves lethality, but provides protection by decreasing friendly fire casualties. The panel supports this initiative that may provide short and long term payoffs.

Robotics

Robotics is a technology that is, in turn, very dependent on other technologies, such as sensing, computing and control, actuators, materials, and power generation/supplies. Much work in robotics technology is found in the commercial sector, academia, and government labs. Single task, pick and place technology has been well developed for manufacturing and other applications and is readily available; however, it is not clear to the panel how such a capability would significantly enhance the individual soldier's capability.

On the other hand, variable complex task robotics is an emerging technology and is dependent on progress in a number of other areas such as imaging sensor interpolation and object recognition and reduction of the associated computational burden. Although the availability of the technology is relatively low in the near term, the panel believes that improvements in variable, complex task robotics can enhance the capabilities of the soldier in the long term. Such improvements might occur to enhance local carrying ability, mobility, and endurance. Also the evolution of robotics technology in the future soldier's electronic-based target detection, acquisition, and fire control systems may considerably enhance the soldier's lethality.

Technical barriers inhibiting the application of robotics technology to enhance soldier system capabilities include but are not limited to actuators and power supplies in terms of performance per unit weight.

Finally, the panel wishes to acknowledge the potential usefulness of robotics technology in areas external to the soldier system. Examples include reconnaissance, surveillance, target acquisition, mechanical mules, and so on.

Advanced Materials.

In examining the key technology of advanced materials, the panel wishes to acknowledge the existence of excellent work going on within and outside the Army in areas dealing with composites, ceramics, polymers, electronic and opto-electronic materials, to cite but a few examples. Furthermore, work underway in these fundamental areas, in turn, underpins many important key technologies and Soldier System capabilities. For example, advanced materials have already impacted, and are expected to continue to contribute substantially to improving the soldier's body armor while reducing weight. In general, materials that provide both increased strength and reduced weight are prime candidates to favorably impact the Soldier System. Advanced materials also have a role to play in reducing a soldier's observability on the battlefield.

In examining the subject of advanced materials, the panel commends the Army for their work in enhancing soldier survivability through improved protective vests and helmets. Furthermore, it encourages the use of recent advances in materials technology to increase the protection, increase the strength, reduce the weight, reduce the observability of those objects worn or carried by the individual soldier. The panel believes that by taking advantage of current and near term advances in materials technology, the capabilities of the soldier can be considerably enhanced.

The panel also believes that reduction of the individual soldier's observability on the battlefield is an important goal. With regard to passive techniques, the panel believes that modest gains are possible. However, with respect to adaptive control of absorption and reflection properties, and biomaterials for chameleon-like camouflage, the panel's judgment is that the availability and the value added to the soldier's capability is relatively low in the near term.

Although not referred to in the chart, the panel does wish to encourage continued aggressive research and development in high energy density sources of electric power for the soldier system, protective materials against laser weapons, and carbon filter replacements using reactive polymers.

Ultra-Small Electronics and Opto-Electronics

There is no doubt that current as well as future technology advancements in microelectronics and opto-electronics can significantly enhance the individual soldier's capabilities. Such enhancement will come about because of improvements in command, control, communications, image (both visual and infrared) and acoustic enhancement, target recognition, navigation, heads-up display, sensors (electromagnetic including laser, acoustic, and ionizing radiation), combat identification friend or foe, and so on. However, there are several challenges to be met including, for example, systems integration, reduction of electric power consumption where possible, improvements in display technology, and uncooled thermal systems sensors. Nevertheless, extensive microelectronics and opto-electronics capability currently exists and is evolving rapidly. Thus, the panel believes that in both the short term and long term the availability and value added to soldier capability is high.

We also favor development of the soldier computer since it could serve an important role in processing information from various sensors (senor fusion) and from other sources (intelligence data fusion). Furthermore, it could provide expert system capabilities to the individual soldier as well as digital signal processing capabilities for image and acoustic enhancement, speech recognition, etc. The utilization of commercial digital signal processing chips should also be considered in addressing these latter needs. The panel believes that the availability and the value added to the soldier's capability is high in both the near and long term. However, the panel recognizes that due to rapidly evolving technology, the soldier's computer in the long term will be considerably improved over that in the short term. Furthermore, it should be recognized that the soldier's computer will only be as successful as the associated software; thus, this latter area must receive very careful consideration.

Combat Casualty Care

The panel review of the soldier as a system found combat casualty care capabilities to be recurrently discussed by both user and provider groups. Until a wounded or injured soldier is evacuated from the tactical area, the soldier system and Army Medical Command have interrelated responsibilities. This element of the appendix will discuss the findings and the potential directions for improvement.

The findings come from threat and response scenarios, SOF concerns, and tech base initiatives. As commented elsewhere in this report, the limited threat analysis and unknown probability of NBC warfare in the future makes prioritization of prophylaxis and therapeutic NBC measures speculative. However, ballistic, blunt, and thermal trauma is a virtual certainty in any future tactical situation. The current tiered system of progressively increasing levels of medical care that has worked so well in recent conflicts may be inadequate in the future. For instance, both SOF and AirLand Battle-Future war scenarios call for non-linear or scattered engagements. A medical system based on air evacuation is highly dependent on air superiority and would be stretched by the large distances envisioned in a rapidly advancing or dispersed battle plan. SOF rely on stealth and justifiably believe that helicopter evacuation of an injured comrade may compromise a whole units mission. Thus, a major need exists for initial combat casualty care that would allow for longer evacuation times with equal or improved outcomes. Definitive initial care can not be provided to the injured on the battlefield as the continuing care and recovery period required after most injuries make this concept impractical. Another finding by the ASB is the emerging technology base in the acute trauma field. The Army has pioneered research into blood substitutes. Although this function is being phased out with the closing of LAIR, multiple biotechnology companies have entered the field in the past four years. Past Army support to create this field has created an intensely competitive, high investment situation in the commercial area. Other Army inventions include hyper tonic, light weight volume expanders for hemorrhagic (blood loss) shock. In addition, the Army is leveraging commercial research in novel biotechnology areas. Field administered drugs may prevent common complications such as vital organ damage or infection that is commonly seen following trauma (see Biotechnology). Other tech base initiatives have obvious applications in combat casualty care. Expert reference systems hardware is a component in SIPE. An expert system that directs care would greatly increase the medical care capability in the tactical area.

Maximizing improvements in combat casualty care will require involvement of many Army commands. As the AirLand Battle-Future doctrine is revised, thought needs to be directed to whether the current medical system is the most optimal organization considering the logistics effort required to evacuate casualties over greater distances. The development of expert systems will require the medical command to evaluate their usefulness to medics, combat buddies, and potentially to non-medically trained soldiers. If the latter proves out, TRADOC and SOF will need to interface in training and doctrine. Novel pharmaceuticals, when developed, will need to be field tested for applicability and effectiveness. In conclusion, the panel supports the intent and direction of the technology base in the current initiative to improve combat casualty care.

SUMMARY

In developing a technology base for the soldier system, it is essential that systems integration receive careful consideration. Also the panel wishes to stress that in considering the tech base supporting the Soldier as a System, one must be aware of the interdependence of many of the technologies. Finally, the panel recommends the following:

- Establish requirements for the soldier system technology base.
- Carry out formal technology area assessments in light of soldier system requirements.
- Include external peer review as part of the technology area assessment.
- Require consideration of alternative concepts early in the research and development cycle.
- Review and refine investment strategy in view of technology base assessment.

APPENDIX F

SUMMARY ASSESSMENT OF ELEMENTS OF THE TECHNOLOGY PROGRAM SUPPORTING SOLDIER AS A SYSTEM

Assessment of Elements of the Technology Program Supporting Soldier as a System

As previously stated, the panel reviewed over the course of six months many programs being undertaken as a part of the overall Soldier System technology effort. Many of these programs appeared excellently conceived, and the method of cooperation between the government agencies and the military industrial base of US companies appeared to emphasize the capabilities of both sectors.

In particular, the programs of the Electronic Technology and Devices Laboratory appeared to have an exemplary process for stimulating interest within the industrial community. A fair and equitable method has been worked out concerning data rights, such as to both provide the government what it needs and to act as a stimulus to private investment in the technologies of importance to the government.

Recognizing that there were a very large number of programs discussed during the ASB study, comment on all of the programs is not possible in the restricted space available in this annex. We have, therefore, chosen to comment primarily on aspects of programs where some thought should be given to program reassessment.

During the course of this study the members of this Army Science Board panel have had several extensive discussions of the technology now being undertaken in support of the Soldier as a System. This section of the ASB report provides to the Army and to the technical management of these programs impressions gained by the ASB panel from these discussions.

These impressions are presented for two reasons. The first is to provide a context for the proposed management and process modifications contained throughout the report. The second reason is to provide to the Tech Base Executive Steering Committee (TBESC) a set of outside perceptions of the programs which they selected and which the TBESC is now monitoring so that they may consider changes to those programs.

We recognize that these impressions may be different than those obtained from other groups. We present them in the hope that they may be helpful in the formulating of a strong ongoing Soldier as a System technology program, believing that one of the ways to obtain a strong program is to solicit from a broad range of sources impressions from which informed judgment and direction can be formed

Soldier Integrated Protective Ensemble

We see the Soldier Integrated Protective Ensemble (SIPE) program to be a pioneering program for the exploring of the operational utility of an integrated assembly of soldier technology. We support both the concept of SIPE and also the detailed program now under way.

The program provides a candidate architecture for assembly of various technology programs previously investigated individually. It further provides a mechanism for operational testing of the assembly of augmented soldier capabilities. While not necessarily endorsing the exact details of some of its systems, we endorse the concept and expect the program to provide important and otherwise not available insights into the ability of soldier technology to significantly augment the future soldier in combat operations.

The reach of the SIPE program is not sufficiently far advanced as to make certain the exact results which can be expected from the tests now scheduled for 1992. In that sense, we believe SIPE to be a proper balance between technical promise and uncertainty of execution. In other sections of this report, we suggest that SIPE, assuming that it continues to mature properly, be extended to become a regularly scheduled opportunity for the soldier technology base to evaluate the potential for improved soldier performance when supported by an integrated assembly of new technological devices.

Enhanced Soldier System (Exoskeletal)

The ASB panel finds itself less enthusiastic than the Army that the devices now proposed for further enhancing soldier capabilities can be accomplished within the foreseeable future in a manner practical for operational use and within reasonable cost.

Without suggesting that current activities be eliminated, we suggest that the emphasis given them should be re-evaluated and that other operationally specialized options for the use of these technologies be added to this challenging Soldier System application (remote mine clearance, loading of shells, and heavy maintenance, etc.).

Joint Family of Operational Rations

We have been continually impressed by the quality of recent Army technology accomplishments in the area of development of operational rations. Those accomplishments have significantly contributed to a better quality of life for the deployed soldier. We wish to compliment both that work and the people who have accomplished it.

We do, however, suggest that current limitations in soldier quality of life with respect to rations may lie more in the area of logistics and force structure support to the provisioning of rations. While we do not question continuation of a quality program for ration improvement, we do feel that the emphasis given to some peripheral issues may not be either operationally desirable or cost effective.

The thrust of our suggestion is that TBESC may wish to ensure itself that the dimensions of the program now underway are appropriate in the light of other technology options not now able to be funded.

Highspeed Mass Assault Air Drop System

This ASB panel considers this area to be of considerable importance, probably warranting greater emphasis than it is now achieving in today's technology program. We further encourage the Army to look more broadly within the military services and private industry for innovative solutions to current jump hazards. We also encourage that a greater portion of the funds programmed to this area be put outside the Army as a method to encourage this broader participation.

Individual Command and Control Systems

We feel this area which provides inter-soldier communicanons, target acquisition capability and helmet interface to information systems to be of exceptionally high pay-off and encourage continued exploration of both conceptual alternatives for implementation and hardware embodying new technologies for test.

However, we encourage concentration on relatively near term solutions and implementations which use commercial architectures and from which commercial sub-systems can be drawn. If this capability is proliferated as we expect, it will be particularly necessary that the cost per item not be larger than absolutely necessary.

We also caution against concentration solely on the most complicated and highest performance systems of vision presentation and security coding. The broad benefit of these systems may be so high that balancing cost and performance may be necessary in order to allow wide usage of this important technology by the soldier. We fear that presently-conceived implementations may be so costly as to prejudice their broad introduction into the field.

This ASB panel favors a command and control architecture as decentralized as possible, where all elements of this individual command and control system are able to operate in the absence of the others, anticipating that the reality of procurement will preclude an "all or nothing" approach.

We also wish to emphasize the importance of this sub-system's ability to effectively interface with those equipments of great importance to the soldier, not contained in the formal Soldier as a System assembly. For example, proper interfacing with the Squad Automatic Weapon and the AAWS-M are crucial. Attention to these important outside interfaces was not evident in our review.

Family of Medical Systems

This activity is considered to be of the absolute highest priority and importance. We have found the work to be of excellent quality. However, we believe that there could be improvement in the integration of these medical systems into the rest of the Soldier as a System components. For example, in remote combat care, the diagnostic information system eventually to be provided in the field needs to have an operationally effective interface with the vision and command and control systems discussed in the preceding section. This may be required in order to effectively input casualty care information to the companion soldier in the field.

We do particularly wish to compliment the medical community on the quality of their programs and their obvious applicability. We do, however, believe there may be more optimism than is warranted in the discussions of what may be possibly achieved in the near future.

Objective Individual Combat Weapon

We believe that the original Soldier System objective, an improved soldier rifle, based on a 90 percent probability of hit to be a very important objective, and were disappointed to find that this objective was abandoned as a result of discussions with our group. Particularly disillusioning was the revised claim of no requirement in the face of concession that the particular solution being proposed was of questionable merit. What we had suggested was that the particular embodiment being considered had, to some of us, a low probability of success, not that the need was unreasonable.

The ability of the normal dismounted soldier to fire his rifle accurately during the stress of battle is known to be diminished from his performance on the rifle range. There appeared to at least one member of our group to be an easy-to-implement method to improve this accuracy, built upon the already made commitment to provide rifle-mounted infrared night sighting equipments. The essence of the idea was to provide in that night sight equipment an option to temporarily interrupt electronically the rifle firing circuit until the target is boresighted with the image of the target in the infra-red scope. Since battlefield experience has shown that infra-red scopes detect men against operational backgrounds as well, if not better, in daytime as in night, the device could have day/night capability. Almost all of the circuitry required for accomplishing this task (already widely proven in many missile tracking systems) will already be available within the basic night equipment (e.g., raster scans and target imaging) so the scheme could be implemented with little cost and no weight or other operational problems.

Whether this or some other method is developed, we believe that technology can straightforwardly alleviate the known combat stress degradation of rifle firing accuracy.

This ASB panel concurs with many other groups that have looked at this issue. We believe the importance of increasing current capability of personal weapons to be of lesser importance than many other soldier needs, except perhaps in the case of the needs of the special forces. At any rate, Army development of further personal weapon technology should be heavily dependent on the needs of the SOF.

Training Systems

We strongly endorse technology development to allow increased capability development of the skills of the future soldier through use of advanced training technologies. However, we do not find that the programs of the Army Research Institute (ARI) and the RDA programs within the TBESC control are particularly well coordinated. At the present time, the SIPE ATTD does not appear to include monitoring capabilities required by ARI for its man-evaluation programs and for optimal training evaluation.

Stronger ARI influence on the activities of the TBESC appears warranted to ensure the incorporating of training capability into the future integrated soldier suite of equipments. For example, the soldier computer being explored as an element of the soldier system probably needs to have as one of its primary obligations the data management of the real-time training and evaluation process. In a sense, the soldier computer might well be analogous to the embedded computer which now drives Patriot and MILES systems today.

Further, fundamental research in parallel processing looks especially applicable to soldier modeling, since many somewhat independent soldier systems will be acting in parallel. We also encourage the advanced development community to strongly press the research community for new technological methods to model human systems.

In our view, an extensive data base exists already within the ARI community, and the emphasis should now be on how to use this data base and how to verify the results of these new models of human performance in combat.

Non-Conventional Incapacitation.

The CRDEC $15M five year funded level of exploration of 6.2 opportunities for non-conventional incapacitation appears to this panel to be far in excess of the probable payoff of this effort. Considering the overall paucity of funds for Soldier System 6.2 technology explorations, the panel questions the wisdom of so large a commitment to this speculative area.

Leap-Ahead Technology.

In the presentation of this $2M per year technology program, there was not an appreciable coupling of these programs to other main stream Soldier System needs, appearing somewhat as a grab-bag of potential areas of investigator interest. While some level of LABCOM discretionary funding is doubtless desirable, a careful look should be taken at least yearly to ensure the results of these programs are adequately focused on the primary needs of the Soldier System.

Individual Fighting System.

The objective of the program seems entirely appropriate, being a fundamental assessment of appropriate technologies for a 21st century fighting suit. However, the fact that no funding stream is identified until 1995 appears awkward. We feel that SIPE technologies already have been selected and that it is now appropriate to start the next generation technology selection process rather than postponing it until 1995.

Fighting Suit Design.

The fighting suit technology programs shown this panel appeared to concentrate on providing the greatest possible protection to the soldier from contaminating agents, hopefully with adequate fighting capability in the variety of conditions faced by soldiers.

In the light of the comparatively infrequent expected occurrence of the design-stressing chemical environment, perhaps the design requirements of the fighting suit should be maximum fighting capability in a non-chemical environment with, hopefully, minimum acceptable protection in the chemical environment.

This panel suggests that at least two parallel fighting suit programs be conducted with comparable resources assigned each; one of the kind being pursued now and one which maximizes effectiveness in a non-chemical environment, but which minimally protects against possible chemical usage. When completed, the user could explore the capabilities of each and more knowledgeably decide what he wishes to procure.

Power Systems for Soldier Applications.

From this panel's viewpoint there appeared to be an over-concentration on portable fuel cell applications in the technology program supporting the dismounted soldier fighting in chemical protective suits. Long term considerations of size, cost, and fuel availability make doubtful in many of our minds the probable fruition of this power cell approach to this application.

Further, it appeared that programs were justified on the basis of requirements for very extended periods of separation of one soldier from another. In the case of dismounted soldiers, it appears to us reasonable to compare the demands of the entirely self sufficient soldiers with those where a squad was designated the self sufficient element. The ensuing potential economy and weight savings of this later situation should be examined to ensure that the restrictions of the present requirement are appropriate.

Many in our panel favor four to five hour power storage through improved technology batteries, rechargeable at a single squad power source, rather than burdening the soldier with long life individual power supplies. Such a system of rechargeable supplies would also, of course, support the electronics requirements of the non-suit fighting environment.

APPENDIX G

PARTICIPANTS LISTING

PARTICIPANTS

The Membership of the Army ScienceBoard Summer Study on Soldier as a System was as follows:

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APPENDIX H

MEETINGS

MEETINGS

Introduction and Background (General Meeting), the Pentagon, 5-6 February 1991

Threat and Requirements (General Meeting), US Army Infantry School, Fort Benning, GA, 5-7 March 1991

Technology Area Assessment and General Meeting, AMC, Adelphi, MD, 26-28 March 1991

Soldier Integrated Protective Ensemble (Site Visit), NRDEC, Natick, MA, 30 April 1991

Technology and Acquisition (General Meeting), NRDEC, Natick, MA, 1-2 May 1991

Technology and Acquisition (General Meeting), CECOM, Fort Monmouth, NJ, 12-13 June 1991

Medical RDA Processes (Site Visit), MRDC, Fort Detrick, MD, 18-20 June 1991

NOTE: Minutes of these meetings are available in the ASB office.

APPENDIX I

GLOSSARY

GLOSSARY

AAE	Army Acquisition Executive
AAWS-M	Advanced Anti-Tank Weapon System-Medium
ACEB	Army Clothing and Equipment Board
AI	Artificial Intelligence
ALB-F	AirLand Battle-Future
AMC	Army Materiel Command
AMSAA	Army Materiel Assessment Agency
ARDEC	Armament Research, Development and Engineering Center
ARI	Army Research Institute for the Behavioral and Social Sciences
ASB	Army Science Board
ATBMP	Army Technology Base Master Plan
ATTD	Advanced Technology Transition Demonstration
BDP	Battlefield Development Plan
BDU	Battle-Dress Uniform
BRDEC	Belvoir Research, Development and Engineering Center
CBRS	Concept-Based Requirements System
C&C	Command and Control
C3	Command, Control, and Communications
C3I	Command, Control, Communications and Intelligence
CECOM	Communication-Electronics Command
Chem/Bio	Chemical/Biological
CIE	Clothing and Individual Equipment
CINC	Commander-in-Chief
CONUS	Continental United States
CRDEC	Chemical Research, Development and Engineering Center
CSA	Chief of Staff of the Army
DARPA	Defense Advanced Research Projects Agency
DCSLOG	Deputy Chief of Staff for Logistics
DCSOPS	Deputy Chief of Staff for Operations and Plans
DCSPER	Deputy Chief of Staff for Personnel
DESC	Defense Electronics Support Center
DGSC	Defense General Support Center
DLA	Defense Logistics Agency
DNA	Defense Nuclear Agency
DOE	Department of Energy
DPSC	Defense Personnel Support Center
ETDL	Electronics Technology and Devices Laboratory
FAST	Field Assistance in Science and Technology
GPS	Global Positioning System
GT	Generic Tasks
HDL	Harry Diamond Laboratories
HEL	Human Engineering Laboratories
IFF	Identification Friend or Foe
LABCOM	Laboratory Command
LAIR	Letterman Army Institute of Research
M/GT	Missions/Generic Tasks
MOPP	Mission Oriented Protective Posture
MOUT	Military Operations in Urban Terrain
MRDC	US Army Medical Research and Development Command

MTL	Materials Technology Laboratory
MWR	Morale, Welfare and Recreation
NASA	National Aeronautics and Space Administration
NBC	Nuclear, Biological and Chemical
NCO	Non-commissioned Officer
NDI	Non-developmental Item
NIH	National Institutes of Health
NRDEC	Natick Research, Development and Engineering Center
OSD	Office of the Secretary of Defense
OTSG	Office of the Surgeon General of the Army
PASGT	Personnel Armor System, Ground Troop
PEO	Program Executive Officer
PM-ALSE	Product Manager - Aviation Life Support Equipment
PM-CIE	Project Manager - Clothing and Individual Equipment
PM-NVEO	Project Manager - Night Vision and Electro-Optics
R&D	Research and Development
RDA	Research, Development and Acquisition
RDTE	Research, Development, Test and Evaluation
SARDA	Office of the Assistant Secretary of the Army (Research, Development and Acquisition)
SAW	Squad Automatic Weapon
SEP	Soldier Enhancement Program
SIPE	Soldier Integrated Protective Ensemble
SMP	Soldier Modernization Plan
SOF	Special Operations Forces
SSM	Soldier System Materiel
TAA	Technology Area Assessment
TBESC	Technology Base Executive Steering Committee
TBSWG	Technology Based Seminar War Games
TO&E	Table of Organization and Equipment
TRADOC	Army Training and Doctrine Command
TSM	TRADOC Systems Manager
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
USATAP	U.S. Army Support Activity at Philadelphia
USSOCOM	United States Special Operations Command

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