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SOLDIER INTEGRATED PROTECTIVE ENSEMBLE (SIPE) ADVANCED TECHNOLOGY DEMONSTRATION (ATD)

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13. ABSTRACT *(Maximum 200 words)*
The Soldier Integrated Protective Ensemble (SIPE) Advanced Technology Demonstration (ATD) was the U.S. Army's successful initial attempt to apply a systems approach to meet the needs of the 21st Century Soldier. This report presents an in-depth look at the actual field demonstration of SIPE and the ATD process. The SIPE ATD demonstrated, in an operational environment, the capabilities that integration of state-of-the-art technologies applied via a Soldier Systems approach could afford the individual soldier. It led to a clear definition of requirements for the dismounted soldier as spelled out in the Mission Needs Statement (MNS) for the Land Warrior (formerly the Enhanced Integrated Soldier System - TEISS). The SIPE ATD demonstrated signficant improvements in the dismounted soldier's ability to shoot, move, communicate, and survive. A detailed discussion of the ATD process lessons learned is included in this report, in addition to discussions of key recommendations.

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PREFACE

This Soldier Integrated Protective Ensemble (SIPE) Advanced Technology Demonstration (ATD) was a fully coordinated effort between the materiel developers (U.S. Army Materiel Command (AMC), and the user, U.S. Army Training and Doctrine Command (TRADOC) – U.S. Army Infantry School (USAIS)). The lead organization for managing and executing this effort was the U.S. Army Natick Research, Development, and Engineering (RD&E) Center (NATICK).

SOLDIER INTEGRATED PROTECTIVE ENSEMBLE (SIPE) ADVANCED TECHOLOGY DEMONSTRATION (ATD)

EXECUTIVE SUMMARY

The Soldier Integrated Protective Ensemble (SIPE) Advanced Technology Demonstration (ATD) was the U.S. Army's successful initial attempt to apply a systems approach to meet the needs of the 21st Century soldier. A three year 6.3A program initiated by the Department of the Army in 1990, SIPE provided a "proof of principle" of the Soldier as a System. The SIPE ATD demonstrated, in an operational environment, the capabilities that integration and aggregation of state-of-the-art technologies applied via a Soldier System approach could afford the individual soldier.

The SIPE ATD led to a clear definition of requirements for the dismounted soldier as spelled out in the Mission Needs Statement (MNS) for the Land Warrior (formerly the Enhanced Integrated Soldier System -TEISS). These requirements are being transitioned to a full scale development (6.4) program as of FY94. This program will concentrate on fielding the most mature and viable SIPE technologies and capabilities. As the first ever ATD, SIPE also provided a number of lessons learned on how to conduct such demonstrations. These lessons learned are being applied in the follow-on 21st Century Land Warrior Top Level Demonstration (21 CLW TLD), a 6.3A effort scheduled for FY94-98. This project, which will include the Generation II Soldier ATD (Gen II ATD), will focus on linking the individual soldier into the digitized command and control network, miniaturization of the electronics, weight and bulk reduction, and on small arms protection for the dismounted infantry soldier.

The SIPE ATD was a fully coordinated effort between the materiel developers (U.S. Army Materiel Command (AMC), and the user, U.S. Army Training and Doctrine Command (TRADOC)-U.S. Army Infantry School (USAIS)). The lead organization for managing and executing this effort was the U.S. Army Natick Research, Development, and Engineering (RD&E) Center (NATICK). It was historic in that it focused for the first time on the "Soldier as a System" and represented not only a new way of thinking, but a new way of doing business.

It is essential that the 21st Century soldier reap the full benefits of current and evolving technological advances. The Army can no longer afford to field new technologies in a piecemeal fashion, as add-ons to the soldier "platform", and it will be intolerable to delay their fielding through long, drawn-out development as has been too often the case in the past. Providing the best possible equipment for the soldier, and ensuring that this equipment is used to optimize operational capability, is what the SIPE ATD was all about.

The SIPE system has successfully demonstrated numerous potential benefits in the "soldier as a system" concept. When reduced in weight and size, and field hardened, it will give the dismounted soldier a clear tactical and operational advantage on future battlefields.

Although each of the SIPE components provided the dismounted soldier tactical and operational benefits, the greatest payoff was seen in the synergistic effect of the various components working together, improving survivability and performance on the battlefield.

The Integrated Headgear Subsystem (IHS), Weapon Subsystem (WS), and Individual Soldier Computer (ISC) significantly enhanced lethality by allowing the soldier to detect, identify, acquire, and engage enemy targets at increased ranges, day or night, with improved accuracy. The IHS, WS, and ISC proved to be vital to increasing the squad leader's capability to communicate with both superiors and subordinates, and exercise more positive command and control over personnel, weapons, equipment, information and procedures. The Advanced Clothing Subsystem (ACS) and Microclimate Conditioning/Power Subsystem (MCC/PS) provided multi-threat and environmental protection while allowing the soldier to operate longer in a fully encapsulated mode. The soldier's survivability was also enhanced by the IHS, WS, and ISC because of the ability to operate with greater dispersion, indirect viewing, and increased lethality.

The integrated, yet modular nature of SIPE enhanced mobility by allowing equipment to be configured based on METT-T. As a direct result of the ATD the following capabilities are being transitioned into the Land Warrior full scale development program to be built and fielded to soldiers.

- Soldier to soldier communications
- Integrated video-enhance image intensification(I2)
- Advanced uniform components
- Handwear
- Load bearing component
- Thermal sight
- Individual soldier computer
- Message management/reporting
- Digital compass
- Weapons interface
- Ballistic, laser eye, and respiratory protection
- Integrated body armor/ammunition carriage
- Footwear
- M16A2
- Laser aiming light
- Global positioning/digital mapping
- Video capture

The SIPE ATD demonstrated significant improvements in the dismounted soldier's ability to shoot, move, communicate, and survive. A detailed discussion of the ATD process lessons learned is included in section 3.0 of this report. Also included are discussions of the following key recommendations:

- Involve the user early and often in the ATD process. Critical to success is the early involvement and active participation of the combat, training, doctrine, and tactics developers as well as the operational units providing the test troops, administrative, and logistical support for the field demonstration. Future ATDs must plan for operationally as well as technically sound programs.

- Establish a formal audit trail from ATD results to subsequent requirements documents. It is recommended that a formal audit trail process be defined, incorporating the concepts of objective-driven scenarios and associated measures of merit, linking the ATD data source matrix with the demonstration exit criteria, defining responsible organizations for each data element and finally, clearly delineating the role of the data elements in follow-on effort decision processes.

- Plan for Success. The SIPE ATD VIP days were one of the most important aspects of the ATD. Future ATDs need to place more emphasis on up front planning of the "show" to allow senior leaders and decision makers to participate rather than simply observe.

- Use of a SETA contractor to expedite ATD function and flow. The SIPE ATD had an integrating contractor to assist in the integration of hardware. The burden of integration of the ATD itself fell entirely on the SIPE office. Future ATDs and TLDs should strongly consider use of a SETA contractor.

1.0 INTRODUCTION

The 21st Century Army will be asked to address a spectrum of potential conflicts well beyond the scope of yesterday's orthodox Warsaw Pact scenarios. These conflicts will be highly dynamic, in rapidly changing geo-political situations, of widely varying intensity, and against an expanded range of threats. The US military will be asked to respond to such diverse challenges with a smaller force structure, and as a consequence, tomorrow's soldier must be more lethal, mobile, and survivable to achieve mission objectives.

It is essential that the 21st Century soldier reap the full benefits of current and evolving technological advances. The Army can no longer afford to field these technologies in a piecemeal fashion, as add-ons to the soldier "platform", and it will be intolerable to delay their fielding through long, drawn-out development as has been too often the case in the past. Providing the best possible equipment for the soldier, and ensuring that this equipment is used to optimize operational capability, calls for not only new thinking but a new way of doing business.

This is the rationale behind the concept of the Soldier as a System. The Soldier System yields an integrated suite of modular, interoperable, compatible components (electronics, weapon enhancements, equipment, clothing, etc.) that enhance individual and collective performance while providing balanced multiple threat protection. However, the Soldier System concept contributes more than just integration of component form and function to enhance inter-operability and compatibility. Achievement of the greatest possible benefits through systems' synergies requires total programmatic integration, involvement of the user early and often, development of training and logistics functions concurrent with equipment development, and continuous coordination of all operational aspects impacted by the introduction of new or enhanced soldier capabilities.

This report presents an in-depth look at the actual field demonstration of SIPE and the ATD process. Other documents (listed in the Appendixes) provide specific technical, human factors, and modeling and simulation results.

The rest of this introductory section will provide a brief background to the SIPE ATD, define its objectives, and describe the approach taken to achieve those objectives. Section 2 will follow with field demonstration outcomes, conclusions, and recommendations. Section 3 examines the ATD **process**, listing lessons learned and giving recommendations for future demonstration of this type. Finally a series of Appendixes will

supply the ATD Data Source Matrix, the ATD Evaluation Plan, a summary of key players, and the reference documents alluded to above.

1.1 Background

The Soldier Integrated Protective Ensemble (SIPE) was the U.S. Army's initial attempt to apply a systems approach to meet the needs of the 21st century soldier. The SIPE program, a three-year 6.3A Advanced Technology Demonstration (ATD), provided a "proof of principle" of the Soldier System. The SIPE ATD demonstrated, in an operational environment, the capabilities that integration of state-of-the-art technologies applied via a Soldier System approach could afford the individual soldier.

SIPE, as the first step in the evolution of the Soldier System, was an integrated set of equipment prototypes, most of which were still in exploratory development. The results of the ATD must be viewed with the understanding that some of the technologies involved were not yet mature, the equipment was not field hardened, and in most cases, the prototype gear was bulky and cumbersome.

While the ATD provided much valuable information as to the viability of these technologies and direction for their development, the true value of the ATD lies in its validation of the concept of the Soldier as a System - the synergism and cross-capability transfer which results from the integrated development and operation of equipment specifically targeted to enhance the war fighting capabilities of the dismounted soldier.

For example, the ATD showed:

SIPE enhances individual lethality through improved target detection and engagement, especially under conditions of limited visibility such as night or smoke.

SIPE has the potential to provide improved protection and reduce the chance of fratricide.

SIPE increases unit combat effectiveness by facilitating intra-squad communications and expanding the ability to react to contact and adapt to changing mission requirements.

These capabilities increase the soldier's confidence in himself and his unit, and provide synergistic effects beyond the increase in any single capability. SSG Paul Mewborn, SIPE Squad Leader, 4th Ranger Training Battalion, states it best:

> "The Army's quest for an integrated and modular combat uniform and enhanced components, represented by the Soldier Integrated Protective Ensemble (SIPE), is an outstanding idea. The SIPE Advanced Technology Demonstration displayed the potential to enhance the combat soldier's capabilities. These enhanced capabilities will provide the soldier better command and control, maneuverability, with improved acquisition, and target engagement through limited visibility, better intelligence gathering capabilities and greater survivability on the battlefield. SIPE has **'led the way'** for the individual soldier into the 21st century".

1.1.1 Subsystems and Components

The SIPE system was composed of the following subsystems and components:

INTEGRATED HEADGEAR SUBSYSTEM (IHS)

- Soldier-to-soldier communications
- Hearing augmentation (ambient and long range)
- Weapons interface (M16A2-mounted thermal sight and laser aiming light)
- Integrated video-enhanced image intensification (I^2)
- Video output for I^2, computer, and thermal images (helmet mounted display)
- Ballistic, laser eye, respiratory and aural protection

ADVANCED CLOTHING SUBSYSTEM (ACS)

- Uniform components (chemical vapor undergarment, advanced combat uniform, advanced shell garment)
- Integrated body armor/ammunition carriage
- Handwear (combat, chemical/biological)
- Footwear (integrated combat boot, gaiter)
- Load bearing component

Passive cooling T-shirt

MICROCLIMATE CONDITIONING/POWER SUBSYSTEM (MC/PS)

Active cooling vest
Filter
Blower
Batteries

WEAPON SUBSYSTEM (WS)

M16A2 (standard infantryman's rifle)
Low cost uncooled sensor prototype (LOCUSP) thermal sight
Aim-1D laser aiming light
Long range hearing device

INDIVIDUAL SOLDIER COMPUTER (ISC)

386SX/80mb hard drive
Global positioning system/digital mapping
Message management/reporting
Video capture (thermal and video)

1.2 Objectives

According to the Secretary of the Army for Research, Development and Acquisition (SARDA), the purpose of an Advanced Technology Demonstration (ATD) such as SIPE, is to exploit the potential of the technology and to develop and enable concept options. Its primary orientation is to show technical feasibility of the most important emerging technologies. The pace is set by the maturation level of underlying technologies. User involvement is desirable and occasionally essential. An ATD can be justified by technology push or requirements pull.

Hind sight says that the SIPE project would have produced even greater results had it been conducted as an Advanced Concept and Technology Demonstration (ACTD). An ACTD has as its purpose to mature advanced system concepts with detailed examination of doctrinal/tactical exploitation. Its primary orientation is conceptual assessment and to develop user equity. It is paced by the assessed impact on military capability. User involvement is absolutely essential. It can be justified based on expected military utility

and an understanding of the operational concept. The concept of ACTDs is relatively new and did not exist when the SIPE ATD was conceived. Future soldier system ATDs should be looked at carefully to determine which process is most appropriate.

The objectives of the SIPE ATD were to demonstrate that the SIPE System would:

- improve performance,
- optimize soldier survivability,
- exploit technology opportunities through a system-oriented application of current and near-term technologies,
- provide a basis for definition of requirements for a future Land Warrior System, and
- support development of a Soldier System road map for exploiting high-payoff technologies needed to develop a modular head-to-toe fighting system.

In order to successfully demonstrate superiority over standard combat equipment, SIPE must exceed the existing requirements, or provide new capabilities to the soldier, which increase individual performance and/or survivability. It must not only out perform current capabilities but also be a viable, reliable and logistically supportable system. The purpose of both the ATD and the Soldier Integrated Protective Ensemble is not simply to demonstrate advanced technologies, but to exploit them to the soldier's advantage.

1.3 Approach

The strategy adopted by the SIPE office was to integrate all soldier system developmental efforts to ensure that the soldier, as a system, operates as efficiently as possible. This concept goes beyond the current R&D method of developing compatible components, to complete integration of state-of-the-art components to ensure that the SIPE system is optimized. This approach was intended to eliminate, or at least minimize, the functional redundancies of different components, thus reducing the overall weight and bulk of the fighting system.

The SIPE ATD achieved its objectives by following an overall management strategy consisting of a 6 phase approach:

Phase I-Concept Development

Phase II-Component Development

Phase III-Integration
Phase IV-Initial SIPE Evaluation/Modification
Phase V-SIPE Procurement
Phase VI-SIPE Demonstration/Evaluation

These phases employed a variety of testing and data collection procedures, each intended to evaluate different aspects of combat or technical performance. The ATD integrated data from four basic components: technical assessments, human factors assessments, modeling and simulation, and field demonstrations.

1.3.1 Technical Assessments

Technical laboratory tests were conducted to measure those aspects of equipment performance which can best be captured in structured, scientifically controlled experiments, such as: acoustic testing of the helmet, physiological testing in the environmental chamber, flow rate and pressure drop test of the microclimate conditioning/power subsystem, and acoustic testing of the long range hearing device. SIPE ATD technical assessments were published as formal reports: *Preliminary Assessment of Three Conceptual SIPE Configurations vs. Standard, MOPP 2 and MOPP 4 Clothing Ensembles*, dated 28 Sept. 1992; *Clothing Configurations in Controlled Chamber Configurations; Draft Test Report for the Soldier Integrated Protective Ensemble*, dated 21 Dec. 1992; and *Soldier Integrated Protective Ensemble (SIPE) Advanced Clothing Subsystem (ACS) Phase II/III Technical Report Vol. I & II*, dated 20 Aug. 1993.

1.3.2 Human Factors Assessments

Human factors assessments were designed and conducted to address MANPRINT issues such as man-machine interface, compatibility, comfort, sizing/fit, and mobility, as well as integration, safety, and training. Solving these issues goes a long way toward user acceptance and user-friendly soldier capabilities. Army Research Institute (ARI) gathered data during the field demonstrations and the results are published in *Soldier Integrated Protective Ensemble (SIPE): The Soldiers Perspective*, dated March 1993.

1.3.3 Modeling and Simulation

Computer models can be used to address equipment, individual soldier, and unit performance under conditions which are too dangerous and/or too expensive to replicate in peacetime. This component was responsible for the estimation of survivability and the

casualty reduction potential of the new equipment and its capabilities. Modeling and simulation (M&S) also permits the projection of performance across a wide variety of operational and threat scenarios that can not reasonably be examined in field testing. Because existing modeling and simulation capabilities throughout the Army lacked the level of resolution and detail necessary to adequately model individual soldier issues and capabilities, M&S efforts on behalf of the SIPE ATD consisted primarily of technical analyses which supported: construction of ATD operation scenarios, definition of operational measures of effectiveness for those scenarios, formation of evaluation criteria for SIPE field demonstration exercises, and concurrent development of new M&S tools including the Integrated Unit Simulation System (IUSS), and the Soldier System Hierarchical Model.

In addition, the Institute for Defense Analysis (IDA) ran the Janus Combat Model with the "standard equipped" infantry squad and the "SIPE equipped" infantry squad to generate squad effectiveness (lethality, survivability, and sustainability) estimates. Simulations included squad missions for defense of a position, reconnaissance and ambush in day, night, non-NBC and NBC conditions. IDA's examination of an infantry squad in the SIPE and standard configuration showed increases in the overall effectiveness of the SIPE equipped squad. More importantly, this study exposed the inadequacy of current combat models in addressing dismounted infantry combat. The available methodologies did not properly portray the intricacies of infantry combat, much less the capabilities afforded by SIPE.

Critical characteristics such as fire and movement, intra squad communications, and acoustic detection, to highlight some of the problems, were not modeled or were not represented to the degree required for this evaluation. The basic scenarios are being re-evaluated with a more recent combat methodology and a report will be published separately.

Early development of the IUSS proceeded in parallel with the SIPE ATD, focusing on the creation of the operational scenarios to be used during the field demonstration STS. There was a good deal of cross fertilization between these two efforts. The IUSS was used to show that the use of microclimate conditioning had a positive impact on soldier endurance in temperate/hot environments and allowed mission completion in those conditions. It was also used to demonstrate the impact of various "soldier loads" on mission performance. Ballistic casualties for materials similar to those

used in the SIPE components were used to develop survivability inputs to Janus and IUSS.

After action analysis of the SIPE ATD indicated that future ATDs will benefit from more extensive use of modeling and simulation to conserve limited money and personnel resources. This M&S support will realize in greatest effect if conducted in concert with a more active role for the Battlelabs.

1.3.4 Field Demonstration

Ultimately SIPE and the Soldier System concept can achieve validity only through demonstrated performance of troops under actual field conditions. To this end, the three-year SIPE ATD research and development effort culminated in a field demonstration at Ft. Benning, GA. Test subjects from the 4th Ranger Training Battalion trained and exercised in the SIPE system for more than two months. The field demonstrations consisted of a series of events each designed to explore specific operational capabilities of the Soldier System. Individual task events included: target detection, target engagement (small arms), land navigation and mobility exercises.

The demonstration highlight was a series of Situational Training Exercises (STXs) which assessed the ability of the SIPE squad performing standard dismounted infantry missions including Recon/Hasty Attack, Raid (Support by Fire), Ambush, and NBC Recon. The STX phase highlighted many of the tactical enhancements and unique new capabilities provided by SIPE. During the field demonstration, assessments were conducted by the U.S. Army Test and Experimentation Command (TEXCOM) on target detection, target engagement (small arms firing) and land navigation. The TEXCOM Close Combat Test Directorate provided their assessment in "Test and Evaluation Report: Soldier Integrated Protective Ensemble (SIPE)" dated Feb. 1993. The U.S. Army Infantry School's assessment is in "Draft Test Report for the Soldier Integrated Protective Ensemble Tactical Field Demonstration" dated Feb. 1993.

1.3.5 Key Players

Realization of the Soldier System concept required an unprecedented degree of coordination between the many diverse participants in the equipment development life-cycle. As an example, multiple government and industry organizations forged a historic cooperative alliance to effectively support the SIPE ATD. This massive effort was led and managed by U.S. Army Natick RD&E Center. Major DA players included the Office of

the Surgeon General (ARIEM), Army Research Institute (ARI), Institute for Defense Analysis (IDA), and the Test and Experimentation Command (TEXCOM). The Training and Doctrine Command (TRADOC) players included the TRADOC System Manager-Soldier (TSM-S), the U.S. Army Infantry School (USAIS), and the 4th Ranger Training Battalion. Other AMC agencies involved included Communications and Electronics Command (CECOM), CECOM Night Vision and Electro Optics Directorate (NVEOD), Chemical RD&E Center (CRDEC), Human Engineering Laboratory (HEL), and the former LABCOM's Harry Diamond Laboratories (HDL), and Electronic Technology and Devices Laboratory (ETDL). Each of these participants was critical to the success of the SIPE ATD.

1.3.6 Lead Agency - Natick

A SIPE Management Office was established within the Office of the Technical Director at Natick to plan, direct, execute and manage the SIPE ATD program. The SIPE office was structured and staffed based on the type of expertise required by the major components or subsystems of the SIPE system, i.e. the integrated helmet, clothing, weapon, microclimate conditioning, and soldier's computer subsystems. The SIPE manager and staff worked closely with other project personnel at Natick, as well as other RD&E centers and contractors, to ensure that the technology development efforts and the programmatic elements were closely coordinated and mutually supportive to achieve the goals of the SIPE program. All team members, including outside agencies, were matrixed to the SIPE manager in order to execute required actions.

Matrix management of a project of this scope and magnitude was difficult because of the large number of players and organizations involved. All information flowed centrally through, and all technical and programmatic decisions were made by the SIPE manager in coordination with other appropriate organizations. The SIPE office also worked closely with USAIS to ensure that the program met the anticipated requirements of the user. Natick initially established an internal steering committee consisting of the Technical Director, the Associate Technical Director for Technology and the Directors of the Individual Protection and Soldier Sciences Directorates to oversee the project and provide guidance and direction. To assist in the management of this complex project a SIPE Master Schedule was developed. Team members provided a monthly update of the status of their efforts to DRC for consolidation.

1.3.7 Multi-Agency R&D

The initial plan called for use of existing Memorandums of Understanding (MOUs) between Natick and BRDEC, CRDEC, USARIEM, MTL, CECOM, and MRDC for managing and performing pertinent efforts to increase personnel and materiel performance /survivability. Extensive transfer of Natick project funds was necessary to cover lab and technical testing as well as TDY expenses.

1.3.8 Contractor Support

An Advanced Planning Briefing to Industry (APBI) was held and proved to be extremely beneficial to governmental agencies, as well as industry, in terms of clarifying issues and exchanging information about requirements, capabilities, and technologies. The Request For Proposal (RFP) was written primarily by the SIPE office and the Natick contracting office with input from the user community. This resulted in awards to four major contractors:

Dynamics Research Corporation (DRC), who was responsible for the MANPRINT/Human Factors/ Systems Integration;
S-TRON, who provided the Integrated Headgear Subsystem;
Geomet Technologies, who provided the Advanced Clothing System; and
Mechanical Technologies Inc., who provided the power subsystem.

DRC assisted in managing the complex project by maintaining the SIPE Master Schedule Update. This document was updated monthly with the current status of various elements of the project. Individual plans and timelines were developed by individual team members. DRC had the integration responsibility but because of the centralized decision making, lacked the authority to direct the activities of other players.

2.0 SIPE ATD FIELD DEMONSTRATION

The SIPE ATD demonstrated many tactical enhancements improving the performance of the dismounted soldier. Situational Training Exercises (STXs) served as the vehicle to demonstrate and highlight these enhancements. The ultimate goal was to determine the operational viability of capabilities never before available to the individual soldier.

The Situational Training Exercises (STX) were written by the SIPE office and USAIS personnel using standard Infantry Platoon ARTEP-type missions and common soldier tasks. The SIPE ATD STX consisted of the following vignettes and mission tasks:

Mission Planning	Conduct NBC Recon
Preparation for Combat	Conduct Area Recon
Occupy Objective Rally Point	Conduct Hasty Attack
Cross Danger Areas	Conduct Ambush
Move Tactically	Occupy Support Position as Part of a Platoon Raid
React to Contact	

2.1 Outcomes

During the SIPE ATD, many tactical enhancements were demonstrated to potentially improve the performance of the dismounted soldier. The SIPE system, when reduced in weight, size, and when field hardened, will give the dismounted infantry soldier a clear advantage over the standard equipped opposing force. The SIPE ATD Situational Training Exercise (STX) served as the vehicle in which many of the tactical enhancements were demonstrated, and proven. This section will list some of the tactical enhancements that the Soldier Integrated Protective Ensemble affords. The following list highlights many of the operational payoffs that SIPE and the Soldier System approach afford:

* Improved survivability
* Improved engagement performance
* Faster reporting of battlefield information
* Faster response to changes in mission/situation
* Improved mission duration or effective mission truncation

* Improved METT-T (Mission, Enemy, Troops, Terrain-Time) flexibility

* Interoperability of system components

* Potential reduction in weight and bulk

2.1.1 Mission Planning

The IHS and ISC expedited mission planning by allowing the SIPE squad leader to receive mission orders, to include tactical, obstacle, and fire support overlays, complete color intelligence photographs, and thermal images, detailing friendly and enemy positions in near real-time. Terrain analysis and route planning could be accomplished using global positioning/digital mapping. Orders and plans could then be transmitted from the SIPE squad leader to other SIPE equipped soldiers in a matter of minutes. All elements of the squad could be briefed on the intra squad communications system simultaneously, without having to move from flank security or listening/observation post positions. This also reduced the potential for confusion and misunderstanding of the commander's intent.

The modular nature of SIPE allowed the squad leader a good deal of flexibility in mission planning to configure his soldier's equipment based on the factors of METT-T. The load expert system could be used to develop precise load plans based on individual height, weight, and duty position of each soldier.

2.1.2 Preparation for Combat

The IHS soldier-to-soldier communications provided continuous verbal communication between leaders and soldiers. Intra-squad communications were used to verify combat equipment checks and to ensure all soldiers were properly prepared for combat without having to rely on visual contact or hand and arm signals. This is particularly significant during darkness or conditions of limited visibility. They were also used to issue last minute changes to the mission, routes, tactical situation and instructions to all squad members simultaneously. Prior to movement, rehearsals and back briefs were conducted using intra-squad communications.

2.1.3 Move Tactically

During the tactical foot march the intra-squad communications allowed squad members to disperse farther (up to three times) than normal. The intra-squad radio allowed the squad leader to control the rate of movement, adjust the movement formation and interval between soldiers without having to maintain visual contact, use hand and arm

signals, or shout verbal commands. This is a significant capability in situations that require early warning, light and noise discipline, stealth, and to overcome the noise of combat. It was used to continually update soldiers on the tactical situation and to rapidly and safely negotiate obstacles and danger areas. Team leaders could provide instant and accurate feedback to the squad leader which aided in decision making.

The IHS and ISC global positioning system and digital mapping allowed the squad to stay oriented on the planned route without having to stop frequently and rely on the "poncho and flashlight" method to check the map. It also reduced navigational errors. Per-formatted situation reports could be rapidly and digital transmitted to higher headquarters.

2.1.4 Cross Danger Area

Using the IHS intra-squad communications and the ISC global positioning/digital mapping, the SIPE squad leader was able to receive feedback from squad members, pinpoint the squad's location in relationship to the danger area, assess the situation, and formulate and disseminate instructions to all squad members. The near side security party was deployed, clearing party briefed and deployed to secure the far side, and the all clear given using soldier-to-soldier communications.

The Weapons Subsystem was effectively used to cross danger areas. Thermal sights were used on the flanks and by the clearing party to ensure the area was free of enemy personnel before, during, and after crossing the danger area. The laser aiming light was used to divide sectors of fire for the teams and to identify targets. The long range hearing device was also employed to clear the flanks and far side.

Employing this technology allowed the SIPE squad leader to maintain positive control over squad members while crossing danger areas, and reduced the crossing time from 15-20 minutes to less than 4 minutes on the average. This also facilitated the consolidation and reorganization phase of the operation on the far side of the danger area and allowed the SIPE squad to rapidly continue their mission.

2.1.5 React to Contact

Upon contact with the enemy, soldier-to -soldier communications was used to disseminate the direction and distance to the enemy, issue orders, instructions and courses of action. Once the squad separated into fire support and maneuver elements, the SIPE squad leader maintained positive control, coordinating fire and movement using the intra-

squad communications. This eliminated the difficulties and confusion of trying to communicate by shouting over long distances while receiving incoming enemy fire. The squad leader and team leaders were clearly understood during the entire engagement. Status and condition of all soldiers were maintained throughout. Soldiers kept their buddies informed of such actions as "Cover me. I'm changing magazines." After the engagement, reorganization and consolidation were accomplished faster and with more positive control because of the intra-squad communications. Consolidation reports were passed up the chain of command faster and more accurately.

The synergistic effect of the IHS, ISC, and Weapons subsystems allowed the SIPE squad to rapidly locate the enemy and gain fire superiority by using the thermal sight and aiming light to place well aimed, accurate fire on him. The thermal sight's ability to accurately observe through battlefield smoke and obscurants, allowed the SIPE squad to use more smoke to conceal their own movement while maneuvering and firing on the enemy. Because of the increased accuracy of fire, fire suppression, and situational awareness, the maneuver element was able to move under less accurate and intensive fire from the opposing force. Another major benefit of this synergistic effect is the greatly reduced potential of fratricide. During the encounter, using video capture, photographs of enemy soldiers and positions could be included with situation or spot reports for instant intelligence processing. Pre-formatted calls for fire could be transmitted and processed faster. After the engagement the long range hearing was used to determine if the area was still hostile without exposing friendly troops.

During the engagement the ACS integrated body armor/ammunition carriage allowed soldiers to carry ammunition pouches and store ammunition in the magazine pocket on the ballistic vest. This made ammunition readily available to the soldier and provided added ballistic protection. The SIPE vest, properly configured, is easier and faster to put on and take off than the conventional PASGT vest and LBE.

2.1.6 Occupy Objective Rally Point (ORP)

Prior to occupying the ORP the SIPE squad leader called a security halt. Using the ISC global positioning/digital map and digital compass, the squad leader verified the squads location in relationship to both the ORP and the final objective. He then plotted the distance and route to the ORP. This minimized the possibility that the squad would become lost, approach the ORP from the wrong direction, move too close to the final objective, and compromise the mission by being observed by the enemy. From the security halt, under

the cover of darkness, the squad leader led one fire team to recon and secure the ORP. Once the recon was complete and the ORP determined to be free of enemy, the SIPE squad leader transmitted direction and distance, using the intra-squad radio to the remaining fire team in the security halt position and controlled their movement to the ORP. This eliminated the need for the squad leader to return to the security halt position to bring up the remaining personnel and risk compromise by unnecessary movement. The fire team entering the ORP was observed using the thermal sight, challenge and password were exchanged over the intra-squad radio and soldiers were directed to their positions using thermal sights, aiming lights and soldier-to-soldier communications.

During occupation of the ORP the thermal sight, aiming light, and long range hearing were used to increase the squad's all around security. A clearing party was sent outside the ORP to ensure the surrounding area was free of enemy activity, keeping the squad leader informed via the intra-squad communications. While in the ORP, final personnel and equipment checks, a review of actions on the objective, final plans, changes, and back briefs were all done using the soldier-to-soldier communications. This ensured that each man knew his job and understood the squad's overall mission. Using the intra-squad communications eliminated excessive movement within the ORP, maintained stealth and control, increased security, reduced the possibility of being compromised and saved 30-45 minutes in the ORP.

2.1.7 NBC Recon

During the NBC recon mission the SIPE squad operated in the fully encapsulated mode. All major subsystems of SIPE come into play in a NBC environment. The IHS and ISC were used to navigate and direct the squad to the contaminated area. The intra-squad communications assisted in maintaining control and, unlike current Mission Oriented Protective Posture (MOPP) gear, allowed soldiers to communicate clearly while moving to and through the contaminated area. It also allowed them to clearly transmit pre-formatted NBC reports. The SIPE squad could clearly communicate to issue instructions for security emplacement and marking of the contaminated area. Using the ISC video capture, pictures of the contaminated area could be digitally transmitted to higher headquarters.

The ACS and MCC/PS provided positive pressure breathing and airflow in the XM44 protective mask. Ambient air from the MCC to the torso kept soldiers cool and reduced fatigue, allowing for increased mission or a more rapid completion of the mission

with reduced heat casualties. Soldiers wearing SIPE boots and gaiters experienced increased traction in wet, slippery terrain and on steep slopes. The entire SIPE NBC configuration considerably increased the soldiers' confidence in their protective equipment over current standard MOPP gear.

2.1.8 Conduct Area Recon

The SIPE squad leader received an area reconnaissance mission from higher headquarters via his helmet mounted display, which included a specific intelligence photograph of the area his squad was to recon. Using the IHS and ISC the global positioning/digital map and digital compass, allowed the squad leader to identify the area, confirm his exact location, and plot a route to the objective. Orders and instructions were passed to other squad members using the intra-squad radio.

Upon arrival at the objective the squad used video capture to photograph the area instead of having to rely on the laborious and time consuming task of compiling a sketch. The I^2 and thermal viewer allowed them to accomplish this from a greater stand off distance thereby limiting the squad's exposure and time in the objective area. The I^2 device, thermal sight, and long range hearing were used to detect and identify enemy personnel, vehicles, command bunkers and other valuable intelligence information on the objective. The photographs and other intelligence information were consolidated and transmitted back to higher headquarters, using the ISC pre-formatted messages, as the squad moved off the objective.

Use of the SIPE technology significantly improved not only the quality and quantity of intelligence data gathered, but also the time to process and disseminate it. Pictures are faster and far more accurate than sketches. Reducing the intelligence processing time from days or hours to minutes will greatly influence the commander's tactical decision making in the development of battlefield courses of action.

2.1.9 Conduct Ambush

Higher headquarters gave the SIPE squad leader the mission, via his helmet mounted display, to conduct an ambush and provided photographs of the ambush site. Again, using his IHS and ISC, global positioning/digital map, and digital compass, the squad leader confirmed his location and the ambush site and plotted a route to the ambush location. Soldier-to-soldier communications were used to control movement of his unit to

the ambush site. Once in position video capture was used to send photographs back to higher headquarters for verification.

In setting up his ambush the squad leader deployed the long range hearing and thermal sights on the flanks of the ambush for early warning. The I^2 device, thermal sights and aiming lights were used to divide up the kill zone, designate sectors of fire, identify and acquire targets during the hours of darkness. Indirect fire support requests, situation, and spot reports were passed using pre-formatted messages and the intra-squad radio.

Upon receiving information that an enemy patrol was approaching, the squad leader alerted his team, via soldier-to-soldier communications, to prepare to initiate the ambush. The ambush was initiated with a M18A1 claymore mine when the enemy was in the center of the kill zone. Utilizing the SIPE components synergistically, the squad then delivered a high volume of accurate and well placed fire on the enemy. The command to cease fire and withdraw was given over the intra-squad radio. The squad was out of the area, consolidating and reorganizing before the enemy could respond. The SIPE technology contributed significantly to the planning, stealth, surprise, violent execution, command, and control of the ambush.

2.1.10 Occupy Support Position as Part of a Platoon Raid

The employment of SIPE technology and equipment as well as the tactical lessons learned for this particular mission are much the same as previous missions. Of particular significance in the support role of the platoon raid was the use of the thermal sight to maintain visual contact with the maneuver element, even through smoke. This capability, along with situational awareness, can significantly reduce the possibility of fratricide. The SIPE squad, with its advanced technology could support the maneuver element from unexposed firing positions using indirect viewing and still place effective fire on enemy positions.

2.2 Conclusions

The SIPE ATD has successfully demonstrated numerous potential benefits in the "soldier as a system" concept. The SIPE system, when reduced in weight and size, and field hardened, will give the dismounted soldier a clear tactical and operational advantage over the conventionally equipped opposing force.

Some of the major conclusions, grouped by soldier system capabilities as outlined in Annex K-Soldier Modernization, of the Army Modernization Plan, are:

Lethality--(The soldier's ability to defeat an enemy soldier and his equipment.) SIPE enhances the soldier's capability to effectively acquire and engage enemy soldiers at increased distances, with improved accuracy and greater efficiency, regardless of the time of day or weather conditions. It enhances the leader's ability to accurately direct a lethal volume of fire onto objectives beyond current night vision device ranges and provides the ability to use more smoke and still place effective fire on the objective. With improved communications, response time for fire control is reduced.

Command and Control--(The soldier's ability to direct, coordinate and control personnel, weapons, equipment, information and procedures necessary to accomplish the mission.) SIPE facilitates greater command and control of soldiers in order to optimally influence the battlefield by allowing soldiers to receive and transmit directed, priority information more efficiently and effectively. It provides communications redundancy within the squad and enhances the squad's ability to react to contact. It provides the squad leader positive control over independent movement of fire teams and enhances his ability to change mission-type orders on the move. It enhances battlefield intelligence gathering in near real time.

Survivability--(The soldier's ability to protect himself against threat effects and environmental conditions.) SIPE provides greater personal multiple threat protection from battlefield hazards and enemy weapon systems in a more functional system. It will also aid in the detection of the enemy's presence before the soldiers themselves are detected. It allows greater dispersion of soldiers on the battlefield. It increases detection capability from unobserved positions, at greater ranges, especially during night and limited visibility and significantly reduces the chances of fratricide. It was particularly useful in urban/MOUT situations to "look around corners".

Sustainability--(The soldier's ability to be maintained in a tactical environment.) SIPE will, in the longer term and with further development, provide greater operational time, increased reliability and less maintenance, as well as facilitate overall ease of support to and for the soldier.

Mobility--(The soldier's ability to move about the battlefield to execute assigned missions.) SIPE provides the soldier with greater equipment integration, improved flexibility to configure equipment to meet METT-T requirements, and increased mobility, ultimately leading to a lightened load. It demonstrated the potential to reduce ammunition requirements due to increased command and control, more accurate route planning and fire support employment, decreased need for illumination and the enhanced ability to operate while fully encapsulated.

2.3 Recommendations

Based on the combined results of all components of the ATD, the technologies examined were grouped into three categories:

1) Currently state-of-the-art yet not applicable to an operational mission, needs more research/development, not recommended for Land Warrior or Gen II.

2) Technology capable of improvement in the near term (1 - 3 years) and recommended for fielding as part of Land Warrior.

3) Brass-board/Bread-board technology, capable of improvement in the mid-term (3 - 7 years), recommended for GEN II.

Perhaps the most important facet of these new capabilities is their synergistic effects. Equipment designed to improve communications also increases lethality through more coordinated fire, enhances survivability through increased situational awareness thereby decreasing fratricide and by allowing more dispersed squad operations, and augments sustainability through more efficient and economical squad operations. Similarly improved protection, while maintaining or increasing survivability, increases mobility through decreased weight and enhances lethality by decreasing encumbrance.

Some specific examples:

- Digital message management allows the SIPE soldier to receive mission orders in a remote location, decreasing his dependence on the commander's location, and allowing more dispersed operations, allowing the squad to influence more area and increasing survivability.

- Soldier-to-soldier communications and ISC data management can provide detailed intelligence photos of the objective area, support mission planning and rehearsal

functions, and allow for dynamic planning on the move in quick reaction to changes in METT-T.

- Soldier-to-soldier communications significantly enhance command and control, allowing the squad leader to quickly adjust the movement formation, rate of movement and disseminate mission changes. They reduce the risk of missing a leader's signal as a function of the terrain, cover and concealment, increase situational awareness, especially at night, during limited visibility and during the heat of the mission. They allow greater dispersion of flank security personnel, which when coupled with long range hearing and vision enhancement provides earlier warning of enemy activity. They allow the squad to communicate effectively in the prone position and maintain stealth. The SIPE soldier receives continuous updates of the status of his fellow squad members, enemy location and mission status. This information alone greatly reduces the possibility of fratricide.

- Real-time GPS and digital mapping coupled with the use of a digital compass verify exact position vis-a-vis mission objectives, other soldiers, and the enemy, again improving situational awareness. The laser aiming light aids team leaders in designating sectors of fire. When combined with ability of each soldier to use an integrated night vision and thermal sighting capability, all aspects of lethality, survivability, command and control and mobility are enhanced. SIPE allows the squad to maintain fire superiority on obscured (environmental, smoke, etc.) targets. The team, viewing the laser aiming light through I2, can engage obscured targets without actually seeing them. The SIPE equipped soldier truly "owns the night."

Realization of the full potential of the Soldier System requires the integrated development, not only equipment subsystems and components, but also training and tactics. For example while there is much synergy between sensor capabilities (e.g., target detection using both thermal and long-range hearing capabilities is better than either one alone), full realization of this synergy requires training in using the two systems together, not just gaining proficiency in each by itself. This will require development of appropriate standards to train towards, besides completing development of the subsystem components themselves. While it must be emphasized that the Soldier System is a "total package" product (the greatest benefits are derived from coordinated implementation all subsystems acting in concert). The modular nature of the components allows for incremental addition of various features, recognizing that some of the SIPE technologies, for example are more mature than others.

The technologies most appreciated in the SIPE ATD, and the ones recommended for earliest fielding are:

• GPS, Digital Mapping, and the Digital Compass. This one capability has by far the highest potential for improving the combat effectiveness of the individual soldier, and is decades ahead of the archaic system currently used.

• Thermal Imaging Technology. Although this will require more intense development to decrease size and weight and improve imaging of small low heat targets to take full advantage of its abilities, the concept that SIPE gives each and every soldier night fighting capability is a critical increase in combat capability and is bound to provide a tremendous combat multiplier.

• Video Capture. The ability to transmit will greatly expedite field intelligence capability.

• Individual Soldier to Soldier Communications. These were well liked by all participants, increasing situational awareness and boosting morale ("I'm not alone out here").

• Components of the ACS. Many of these (e.g., gaiters, combat and chemical gloves, armor) provided noticeable, if not dramatic improvements over current gear.

Areas where desirable capabilities were identified, but in which examined technologies need significant modification are:

• Helmet Mounted Display. Much of the information provided was though to be valuable, but the displays where too intrusive, limiting field of vision. Size and look-through capability as well as quick flip-up flip-down capabilities need to be explored.

• Long-Range Hearing. While the increase in distance capability was useful, the degree to which the prototype interfered with close-up capability was unacceptable.

• Micro-climate cooling. The capability provided was extremely well liked and thought to be valuable, but current equipment weight, noise signature and power requirements are prohibitive.

3.0 ATD PROCESS

Because the SIPE ATD was the first of its kind, it provided lessons beyond its intended goal of exploring the operational benefits of the SIPE, lessons pertaining to how to plan and produce an ATD. While the immaturity of some of the equipment and technologies, the limited troop exposure and training time, and the inflexible nature of the testing community's rules prevented the Army from learning a great deal more about the potential capabilities of SIPE, the SIPE ATD is viewed by all who participated as a highly successful program. That said, there are many areas where hindsight can suggest improvements. This section documents those suggestions, as well as recording the practices and procedures which proved effective for this initial ATD. It is intended to provide guidance to others responsible for future ATDs.

3.1 Lessons Learned

The lessons learned from the SIPE ATD cover very detailed observations: how to better structure the ATD planning and organization process, how to select and train test personnel, and how to conduct field exercises. However, as in the ATD itself, while a great deal of valuable information can be gained from close examination of the details, it is a mistake to focus exclusively on the "eaches", the separate components or modules. Much of the most interesting information pertains to top level issues, the synergy between components and the over-riding philosophies of development and operation. Accordingly, the discussion of ATD lessons learned begins with an examination of the fundamental nature of such technology demonstrations, and specifically how they differ from more traditional test and evaluation activities.

3.1.1 Definition of ATD (Demonstration vs. Test)

SIPE, as the first step in the evolution of the Soldier System, was an integrated set of equipment prototypes, most of which are still in exploratory development. One difficulty faced by ATD planners was in overcoming R&D mind sets accustomed to performing operational tests of equipment ready or nearly ready for fielding. Many of the initial (and some not so initial) paradigms suggested for evaluation of ATD results were more appropriate for **test** rather than **demonstration**. Such thinking colored much of the approach to the ATD and, while some testing approaches were adaptable to the needs of the ATD, many were not. As an example, a necessary feature of test procedures is

"repeatability." Tests are scientific experiments. If their results cannot be replicated, then the test has no scientific validity. For a demonstration, on the other hand, the concept of repeatability is not as important. It is more important to solicit the users' opinions and to investigate the possible spectrum of operational responses. Rather than striving for scientific repeatability, a demonstration wants to capture the "feel" of the battlefield, to explore the inconsistencies, inventiveness, and imperfections that are associated with how soldiers actually fight battles. It is also important to realize that demonstrations may focus on **potential** (as opposed to realized) capability. Tests are usually designed to ascertain whether a system meets some set of requirements; the SIPE ATD was designed to illustrate the promise of the Soldier System approach, and to point the way to development of the next generation soldier.

The objectives of, and procedures appropriate to, a demonstration are very different than those of a test. The SIPE ATD, as the first demonstration of its type, provides the first cut at clarification of these differences. Of fundamental importance is the concept of an objective-driven demonstration. Each aspect of the demonstration needs to be tailored to the achievement of specific objectives, usually pertaining to determination of the feasibility of some operational capability or the assessment of a potential benefit. The SIPE ATD was intended to be a demonstration of capabilities and technologies (proof of concept)--not a test.

The SIPE ATD experienced difficulties because of the focus on hardware rather than on capability areas. Adding considerably to these difficulties is the fact that the DA/TEXCOM "rules" for test and evaluation do not accommodate ATDs.

3.1.2 Analysis Plan Requirements

One of the most important lessons learned from the SIPE ATD was the need to avoid the temptation to begin bending metal without benefit of sufficient analytical planning. One of the first milestones of a structured demonstration should be the development of an analysis plan, providing a road map for implementation and operation of analytical tools, data collection methodologies, and report requirements and formats concurrent with development of items to be demonstrated.

The analysis plan should incorporate a Front End Analysis to examine such items as demonstration scenarios, personnel requirements, schedule constraints, and the

establishment of quantifiable baselines against which to compare the items being demonstrated.

3.1.3 Coordination of Participant Organizations

The SIPE ATD did a relatively good job of establishing lines of communication and authority within the participating organizations, but at times had trouble with definition of accountability - who was supposed to deliver what to whom and when. One possible solution to this problem is a contract initiative for a Scientific, Engineering, and Technical Assistance (SETA) contract. Such a contractor is usually responsible for maintaining audit trails of accountability as well as providing unbiased assessment of performance vis-a-vis stated requirements. This function is very different from that of an integrating contractor, whose job is to merge the modules provided by disparate entities into an interoperable system. An integrating contractor's concern is to make hardware work. A SETA contractor's concern is to oversee demonstration execution, ensure personnel and materiel are where they're supposed to be when they're supposed to be there, and assist in the publication of reports and documentation.

Future ATD managers should seriously consider negotiating separate specific MOUs with matrixed organizations in which all parties agree to the process, procedures, formats, amount and type of support, chain of command, decision authority, and responsibilities. In order to give the ATD manager a little more control over the priorities and the process, the MOU should allow the ATD manager to provide, at a minimum, letter input to the performance appraisal of key personnel.

3.1.4 Test Personnel Selection, Training, and Motivation

The Director of Training (DOT), USAIS was supposed to provide instructor certified personnel to be trained on the SIPE equipment. They would write POIs for classroom instruction to cover individual skills for each piece of equipment, to include field/tactical employment, and train the 4th RTB test troops. The RTB squad was supposed to be "certified" as proficient in common tasks, squad ARTEP, and MOS score by DOT. SIPE Operating Rules (SORs) were written for the soldier's computer, soldier communications, augmented hearing, vision enhancement, multi-threat protection, target acquisition and engagement, and SIPE STX collective tasks. This manual was intended as an operator's manual for the SIPE equipment and to assist the DOT instructors in training the test troops. Lesson plans were never prepared and the classroom training never

occurred therefore the trainup was poor. The 4th RTB squad was supposed to be "proficient" in the ARTEP missions (to establish a baseline) and have initial familiarization with how the equipment was to be operated and employed in the field. Baseline performance of the 4th RTB squad was never measured which makes analyzing performance enhancements difficult. Because the test troops were not an intact squad and the trainup was done poorly, execution suffered. This again points out the necessity of having unit integrity and the test troops involved very early in the process. It also highlights the need for the training developers to be actively involved, along with the combat and materiel developers, in the initial planning phases.

Care needs to be given to the selection of troops with regard to unity of command and an appropriate balance of skill, rank , and experience. For the SIPE ATD, troop selection was driven by the size of the SIPE helmet and the cost of the helmet mold. As a result, an ad hoc, composite unit was assembled based on their head size and the ability to wear the helmet. This violates principles of unit integrity, unity of command, leadership and training practices. A better solution might be to create and stabilize a "cohort" type platoon for the duration of the project and involve them from the very beginning. Ideally, an entire infantry company would be given an ARTEP-type mission to conduct and support the ATD. All personnel would be trained to use the equipment and be actively involved the ATD process. One platoon could be designated to do baseline studies and another as SIPE test troops. During the field demo phase some soldiers would be test subjects. Others could be OPFOR, data gatherers, and support troops.

After troops have been selected, much more care needs to be taken with respect to their training and motivation. Again, with a demonstration as opposed to a test, there is little concern with the possibility of skewing results based on rehearsal bias. It is more important to explore the synergy between good training and demonstrated equipment as it relates to operational performance.

3.1.5 Field Exercise Execution

The SIPE ATD proved, yet again, the need for careful planning and adequate fall backs for successful execution of field activities. Contingency plans are needed for bad weather, equipment breakdowns, etc. Consideration needs to be given to the potential requirements for more diverse conditions (night vs. day, cold vs. warm, mix of terrain features).

3.1.6 Getting the Message Out

Above all else, the demonstration is a vehicle to convince or persuade. In order to do this adequately, demonstration results must be visible. Events must be as nearly self-explanatory as possible. Assumptions, procedures, and results must be well documented, concisely but clearly explained, and expressed in contexts which are both meaningful and of high interest to the ultimate end user and decision makers.

One of the most significant factors contributing to the overall success and acceptance of the program was the "VIP days" demonstration at the conclusion of the field demo. It was a tremendous opportunity to "sell" the program to the Army's senior leadership and decision makers. It gave them not only an opportunity to see and hear the pitch, but actual hands-on experience with the equipment. The single most important thing for them (and SIPE) was the opportunity for the warfighting leaders to talk to the soldiers who actually used the equipment. It also gave all the other participants an opportunity to take credit for the overwhelming success of the program.

The SIPE ATD Technology Plan reveals a lack of planning for anything beyond the execution of the field demonstration. Considerable effort and resources (time, people, and dollars) were, in fact, expended in telling the SIPE story; not only at the end but also as the program moved through all phases of development. The importance of these type activities (as well as AUSA and other similar public relations events) should not be overlooked or under-estimated. In fact they should be carefully planned, scheduled, resourced and executed.

SIPE did well with VIP days and presentation of after action briefings and exhibits, but did not do well with respect to timely publication of substantiating detail. Future ATD's must ensure that the "show" is not viewed as the end of the effort; successful completion of the ATD occurs only after all final reports have been published.

3.1.7 Managing Change

The changes that occur over the life of the project can impact the total effort both positively and/or negatively. Changes in purpose, mission, scope, technology, funding, threat capabilities, or key personnel tend to occur in any long term project of this nature. For example, the SIPE ATD was impacted by other significant events: the creation of the TSM-Soldier, Army Science Board Summer Study of the Soldier as a System, and the development of IUSS. It is extremely difficult to anticipate and plan for these kind of

changes. Flexibility is key. When a major change occurs every aspect of the program must be re-evaluated to examine the impact of the change. Although helpful, the SIPE Master Schedule (described in section 1.3) suffered from poor sequencing and timing of events. It lacked a building block approach and, DRC as the integrator, had no authority to direct activities. Future ATD's should retain the quarterly interim proram reviews (IPRs) held during SIPE. These meetings, with all team members to review project status and resolve issues, provide the coordination essential to keep all the players informed and to meet project timelines .

It is absolutely imperative that all key user representatives be involved from the beginning and remain involved throughout; teaming concepts must actively involve the combat developer, training developer, doctrine and tactics developers, as well as the operational units providing the test troops and support for the field demonstrations. Everything that is developed must be based on sound Infantry doctrine and tactics. The Army must plan both technically sound and operationally sound programs for future soldier systems. The test and evaluation community needs to have more flexibility in their process to accommodate unique ATD requirements. Timing of integration efforts is key as it is clearly the most difficult aspect of the systems approach. The tendency is to put it off until too late in the process. Much more of it is needed, much earlier in the process and throughout. There is a fine line between "modularity" and "integration". Input from the user is again critical. Programmatic integration is equally as critical.

Given the enormity of the project, the SIPE office was severely understaffed. Future ATDs of this nature should be staffed with the proper mix of civilian and military (both officer and enlisted) with the appropriate grade, branch, MOS, education, training and experience. Military personnel should be stabilized for the duration of the project to minimize turnover and maximize continuity.

3.1.8 Post Demonstration Wrap-up/Report Production

The other significant activity that lacked sufficient planning attention was a procedure to close out the project and compile lessons learned and the necessary reports. A comprehensive plan should be developed at the beginning of the project to capture not only technical information and evaluation data, but lessons learned throughout the entire process as each phase is completed. Lessons learned should be required of all players, to include contractors, at periodic intervals. Properly done, final reports would be compiled by an independent agency who gathers data, impressions, lessons learned, etc., on a regular basis

and produces a draft final report within a specified period at the end of the project. Concurrent documentation should be an integral part of the evaluation plan.

3.2 Recommendations

This section summarizes a few of the more important recommendations derived from the lessons learned provided above.

3.2.1 Involve the user early and often

All aspects of an ATD are enhanced by the early and consistent employment of well-trained, motivated troops. It is recommended that future ATDs incorporate an entire company (or other unit as appropriate to the demonstration objectives) to conduct and support the operations. It is recommended that such support be defined as a unit mission consistent with the current format of the Army Training and Evaluation Plan (ARTEP) procedures, and that all personnel be trained in these procedures. Such a trained unit would be an invaluable asset in demonstration planning and implementation in addition to such direct roles as providing test subjects, OPFOR members, data gatherers, and ancillary support troops.

3.2.2 Establish a formal audit trail from ATD results to subsequent requirements documents

Ultimately ATD results are intended to drive formal requirements documents such as Mission Needs Statements (MNSs), and provide both technology push and pull, the push provided the DoD technology base, and the pull provided by the users who become aware of technology potentials as demonstrated by the ATD. While SIPE provided insight to the MNS process and some direction for follow efforts such as Land Warrior and 21 CLW, at present there is no formal documentation process to provide the audit trail from demonstration outcomes to quantified data inputs to follow-on processes. The SIPE ATD struggled throughout with the problem of how to define appropriate measures of merit for scenario component outcomes, and how such measures would correlate across ATD component efforts. It is recommended that a formal audit trail process be defined, incorporating the concepts of objective-driven scenarios and associated measures of merit, linking the ATD data source matrix with the demonstration exit criteria, defining responsible organizations for each data element though formal memoranda of understanding, and finally, clearly delineating the role of the data elements in follow-on effort decision processes.

3.2.3 Plan for Success

It is critical that an ATD be an actual "demonstration", a highly visible presentation the ATD outcomes and conclusions. In retrospect, the SIPE ATD VIP days, which fulfilled this function, were one of the most important aspects of the ATD. Future ATD's need to place more emphasis on up front planning of the "show". It is recommended that technologies such as distributed simulation and multi-media presentation be integrated into all phases of the ATD process, from initial planning to final field exercise execution. It is especially important to consider how to use these technologies to provide an interactive component to the demonstration, to allow decision makers to participate rather than simply observe.

3.2.4 Consider the use of a SETA contractor

One of the main themes running through the lessons learned was the overwhelming demands placed on the SIPE office. Contractual support was provided to assist in the development of hardware, but little or no provision was made to support the myriad other technical and engineering challenges involved in conducting an ATD as a valid scientific exercise. Part of the problem was the disconnect between the functions of integrating component **hardware** modules (i.e., the SIPE systems) into an inter-operable system, and the functions of integrating **demonstration** components (i.e., laboratory experiments, M&S, technical test, and field exercises) into a clear, coordinated, and coherent demonstration of SIPE's potential benefit to the soldier. The SIPE ATD had an integrating contractor to assist in the integration of hardware; the burden of integration of the ATD itself fell entirely on the SIPE office. Future ATDs and TLDs should strongly consider use of a SETA contractor. Although some of the SETA functions can in fact be included in the integrating contractor's statement of work, this is not recommended, as a separate SETA contractor, functioning independently, fulfills the role of the "honest broker".

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REFERENCES

REFERENCES

Army Modernization Plan, Volume II, Annex K. Soldier Modernization, HQDA, DCSOPS Jan. 1993.

Comments on SIPE vs. Standard Assessment Draft MFR, Mooney, Cynthia J., 5 Oct. 1992.

Casualty Reduction Modeling: A Quick and Dirty Analysis of Various Theoretical Helmets With and Without Face Shields, O'Keefe, John A. IV., 29 Jan. 93.

Draft Test Report for the Soldier Integrated Protective Ensemble, Deal, Clifford L., 21 Dec. 1992.

Draft Test Report for the Soldier Integrated Protective Ensemble Tactical Field Demonstration, Nahas, Albert J., 3 Feb. 1993.

Evaluation of Thermal Strain During Exercise in SIPE Clothing Configurations in Controlled Chamber Configurations, Cadarette, Bruce S.

Integrated Unit Simulation System: Metabolic Work Rate Support Study, Ramirez, Tammy L., Aug. 1993.

Mission Needs Statement (MNS) for the Land Warrior, formerly The Enhanced Integrated Soldier System (TEISS), HQs DA., 8 Sept. 1993

Preliminary Assessment of Three Conceptual SIPE Configurations vs. Standard, MOPP2 and MOPP4 Clothing Ensembles, Reesee, Robin L., 28 Sept. 1992.

Report of Travel of Ms. Dianne St. Jean and Mr. John O'Keefe to Columbus, Ga. (23-26 March 1992), 27 March 1992.

Soldier Integrated Protective Ensemble (SIPE) Advanced Technology Demonstration (ATD) Human Use Protocol, Cynthia L. Blackwell, Aug. 1992.

SIPE ATTD Technology Development Plan, Fitzgerald, Carol J., Jan. 1990.

Soldier Integrated Protective Ensemble (SIPE) Advanced Clothing Subsystem (ACS) Phase II/III Technical Report Vol. I & II, GEOMET Technologies Inc., 20 Aug. 1993.

Soldier Integrated Protective Ensemble (SIPE): The Soldier's Perspective, Salter, Margaret S., March 1993.

Soldier as a System, Army Science Board, Dec. 1991.

Soldier Evaluation Questionnaire for SIPE, Donald Parks, HRED July 1992.

Soldier System Brochure, Soldier as a System Exposition, Dec. 1991.

Soldier Integrated Protective Ensemble (SIPE) Advanced Technology Demonstration (ATD), Fitzgerald, Carol J., 5-6 April 1993.

Strategic Plan for DoD S&T Thrust 5, Advanced Land Combat, DoD, July 1993.

Test and Evaluation Report: Soldier Integrated Protective Ensemble (SIPE), TEXCOM Close Combat Test Directorate, Feb. 1993.

The Soldier Integrated Protective Ensemble (SIPE) Demonstration Integration Working Group (DWIG) Meeting Minutes 1991-1993.

APPENDIXES

APPENDIX A.

DATA SOURCE MATRIX

Exit Criteria	Title	Executor	Test Method	Data	Units
	Final Sys. Dyn.	HEL	NA	live firing	Exposure time; targets exposed vs. hits
		Eval.	NA	obstacle course runs	time to complete; subjective
			NA	portability/mobil. runs	time to complete; subjective
			NA	form/fit/func.	subjective
	Phase IIb	Natick/ARP	NA	check fit	measurements; subjective fit assessment
	Phase III Fit Test	Natick/ARP	NA	check fit	measurements; subjective fit assessment
	Weight Analysis	Natick/DRC	NA	weight reduc/incr.	weight projection
			NA	deter. CG of Ph III helmet	deviation from head cg
			NA	comp. SIPE vs. Std Cloth.	weights
	Compatibility Test	Natick	NA	assess layer compatibility	cable & hose lengths; subjective
	STX#2-NBC Recon	USAIS	NA	C2&Mobility capabilities	Subjective
			NA	cap-collective MTP task	-
Mod 1:2	ACS Flame/Thermal CIE: Flame Prot.	Natick/GEOMET	ASTM 5903	thermal resistance	thermal resistance
Mod 2:1	Ballistic Testing/	BRL	-	ballistic Data	striking velocity, residual velocity, V50, Johnson Coefficients
	Ballistic:	Modeling		-	data for Cas Red Anal
	Ballistic Testing-	Frag/Laser BRL	-Ballistic Data	V50 V50 w/ 2,4,16,64 grain	velocity for projectile
	Ballistic Testing-	Fragmentation/Flechette BRL	- Fragmentation	frag/flechette protect level Helmet Shell data	Vs, Vr V50 w/ 2,4,16,64 grain Ballistic visor data V0

Exit Criteria	Title	Executor	Test Method	Data	Units
Mod 3	IHS/Soldier's Comp C4I	Natick/HEL	NA	ease of use	Subjective
			NA	acceptability	Subjective
			NA	compatibility	Subjective
Mod 3:1	Soldier's Computer C4I: Sold. Comp.	CECOM/Natick	NA	C4I enhancement	Subjective
			NA	ease of use	Subjective
			NA	reliability	Subjective
			NA	test utility	Subjective
Mod 3:2	GPS Assessment	CECOM/Natick	NA	GPS accuracy	GPS position vs. actual position
	C4I: GPS		NA	evaluate human interface	Subjective
	Orienteering,	TEXCOM	-	navigation w/ GPS	Speed, accuracy Field Demonstration
Mod 3:3	Intra-Squad Comms	CECOM	NA	communication ranges	Distance, terrain, environment
	C4I: Intrasquad		NA	localizations	Distance, terrain, environment
			NA	clarity/intelligibility	modified rhyme test accurate receipt prepared message
			NA	face-to-face comm	modified rhyme test accurate receipt prepared message
Mod 3:1,2,3	STX#1-Move to Con C4I	USAIS	NA	test C2 & mobility	Subjective
			NA	assess MTP tasks	Subjective
	STX#2-NBC Recon*	USAIS	NA	C2&Mobility capabilities	Subjective
			NA	cap-collective MTP task	Subjective
	STX#3-Raid	USAIS	NA	C2&Mobility	Subjective
			NA	cap-collective MTP task	Subjective
Mod 4:1	Electro-Optics/	C2NVEO	NA	low light level vs. resolution	foot lamberts vs. line prs per mm

Exit Criteria	Title	Executor	Test Method	Data	Units
	Electro-Optics:	Night Vision Tech.	NA	distortion	percent changed
		Night Vision	NA	field of view	Horiz degrees, vert degrees
			NA	minimum focal length	Smallest inches to focus
			NA	range	distance seen
	Electro-Optics/	C2NVEO	NA	firing tests	exposed vs hit targets, exposure time
	Thermal Sight		NA	target acquisition	time
			NA	target identification	time
			NA	sight FOV and resolution	Horiz degrees, vert degrees
	Target Detection	TEXCOM	NA	target detection day/night	MOPP0&IV exposed vs. detected at different light levels, range, time
			NA	visual/audio/IR	exposed vs. detected at different light levels, range, time
	Small Arms Firing	TEXCOM	NA	target detection detected	how many targets
			NA	hit	exposed vs hit targets, exposure time
Mod 5:1	MCC/PS Filter Test	CRDEC	-	DMMT Protection Factor	sorbtive capacity
	Chem/Bio: NBC Prot.	Natick	CRDC-SP-8401	vapor challenge/vapor	mg/cm^2 penetrated for given time penetration
	Materials Test.		CRDC-SP-8401	liquid challenge/liquid	mg/cm^2 penetrated for given time penetration
			NA	aerosol penetration	% penetration
			CRDC-SP-8401	liquid challenge/vapor	yes or no penetration penetration
		SIPE C/B Protection	CRDEC	-	aerosol protection -
Mod 5:2	USARIEM Chamber	USARIEM	NA	cont. oper. time	Time, core temp, heart rate, work rate, subjective data
	Chem/Bio:		NA	impact of MCC	Time, core temp, heart rate, work rate,subjective data
	Sustainment		NA	impact of positive	Time, core temp, heart

Exit Criteria	Title	Executor	Test Method	Data	Units
					rate, work pressure breathing rate, subjective data
	Ph II SIPE Sys.	Natick/HEL	NA	assess load distribution	Subjective
			NA	load carrying - marching	Subjective
			NA	compatibility w/ firing pos'	Subjective
			NA	assess form/fit/func.	Subjective
	Final Sys. Dyn.	HEL	NA	live firing	Exposure time,; targets exposed vs. hit
	Eval*		NA	obstacle course runs	time to complete; subjective
			NA	portability/mobil. runs	time to complete; subjective
			NA	form/fit/func.	Subjective
	Heat Stress	USARIEM	NA	work/rest cycles	Report w/ info at 5%, 20%, 50% casualty rates
	Modeling		NA	max work time	Report w/ info at 5%, 20%, 50% casualty rates
			NA	water requirements	Report w/ info at 5%, 20%, 50% casualty rates
	STX#1-MoveCon*	USAIS	NA	test C2&mobility	Subjective
			NA	assess MTP tasks	Subjective
	STX#2-NBC Recon*	USAIS	NA	C2&Mobility capabilities	Subjective
			NA	cap-collective MTP task	Subjective
Mod 6:1	MCC Technical Test	Natick	NA	pressure drop	pressure differential
	MicroClimate:	Blower Eval.*	NA	flow rates	flow rate Thermal Equilib.
	MCC/PS Fitter	Natick	NA	pressure drop	pressure differential Test

Exit Criteria	Title	Executor	Test Method	Data	Units
	MCC/PS Pressure (blower)	Natick	NA	flow rate	flow rate over life of battery
			NA	pressure drop	pressure drop over life of battery
	USARIEM Chamber	USARIEM	NA	continuous operation time	Time, core temp, heart rate, work rate, Testeing* subjective data
			NA	impact of MCC	Time, core temp, heart rate, work rate, subjective data
			NA	impact of positive	Time, core temp, heart rate, work pressure breathing rate, subjective data
	Heat Stress Model*	USARIEM	NA	work/rest cycles	Report w/ info at 5%, 20%, 50% casualty rates
			NA	max work time	Report w/ info at 5%, 20%, 50% casualty rates
			NA	water requirements	Report w/ info at 5%, 20%, 50% casualty rates
	STX#1-MoveCon*	USAIS	NA	test C2&mobility	Subjective
			NA	assess MTP tasks	Subjective
	STX#2-NBC Recon*	USAIS	NA	C2&Mobility capabilities	Subjective
			NA	cap-collective MTP task	Subjective
Mod 6:2	MCC/PS Noise Sign	USAARL	NA	internal noise interference	dBa in frequencies; subjective
	MicroClimate:		NA	system safety analyses	dBa in frequencies; subjective
	Signature MCC/PS Noise Sign	Natick	NA	external noise	dBa while mtd on back
Mod7:1	Load-Bearing -	CECOM/Natick	NA	evaluate user interface	Provide optimum load configurations based on METT-T
	Load Bearing:	Load Expert	NA	evaluate acceptability	Provide optimum load configurations based on METT-T

SIPE SOURCE DATA MATRIX

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Exit Criteria	Title	Executor	Test Method	Data	Units
	Ph II SIPE Sys. Dyn.*	Natick/HEL	NA	assess load distribution	Subjective
			NA	load carrying - marching	Subjective
			NA	compatibility w/ firing positions	Subjective
			NA	assess form/fit/func.	Subjective
	Final Sys. Dyn.	HEL	NA	live firing	exposure time; target hit vs. exposed
	Eval.		NA	obstacle course runs	time to complete; subjective
			NA	portability/mobil. runs	time to complete; subjective
			NA	form/fit/func.	subjective
	Load Profile	Comfort Tech.	NA	load analysis-	Where weight should be carried & LBC, IHS, MCC/PS how
	Analysis		NA	identify stress points	Where weight should be carried & how
			NA	ident. hot spots	Where weight should be carried & how
	Mobility	HEL	NA	compare SIPE/Std baseline	Subjective
			NA	speed over distances	Time
			NA	weight/comfort	Subjective
			NA	assess mobility	Subjective
	STX#1-MoveCon*	USAIS	NA	test C2 & mobility	Subjective
			NA	assess MTP tasks	Subjective
	STX#2-NBC Recon*	USAIS	NA	C2 & Mobility capabilities	Subjective
			NA	cap-collective MTP task	Subjective
	STX#3-Raid*	USAIS	NA	C2 & Mobility	Subjective
			NA	cap-collective MTP task	Subjective

Exit Criteria	Title	Executor	Test Method	Data	Units
Mod 8:1,2,3	SIPE Weapons	Natick	NA	day/night firing	Targets exposed vs hit; targets acquired
	Weapons:	Interface	NA	firing thru obscurants	Targets exposed vs hit; targets acquired
		1. Day Eng.	NA	firing in full encapsulation	Targets exposed vs hit; targets acquired
		2. Night Eng.			
		3. Encap.			
	Small Arms Firing*	TEXCOM	-	target detection	how many targets detected
				recognition how many targets recognized	
				location	how many targets located
				hit	exposed vs hit targets, exposure time
System	Combat Modeling	IDA	NA	squad lethality	% kill vs. various munitions
	Standard Squad		NA	squad survivability	% Survive vs munitions
			NA	squad sustainability	Time to completion
	Combat Modeling	IDA/Natick	NA	squad lethality	% kill vs. various munitions
	SIPE Squad		NA	squad survivability	% Survive vs munitions
			NA	squad sustainability	Time to completion
	AHP-Delphi Proc.	Natick	NA	prioritize attributes	Ratios/weights
	AHP/Military	Natick/ASD	NA	prioritize attributes of soldier capability	Validation of Ratios/weights Pairwise Comp.
			NA		
	AHP Developed MOE	Natick	NA	MOE for SIPE	Ratios/weights
	Helmet Ballistic Modeling/Testing	Natick/ASD	NA	lethal areas	Serious lethal wounds
			NA	lethal wounds	CASRED output
			NA	serious wounds	-

SIPE SOURCE DATA MATRIX

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Exit Criteria	Title	Executor	Test Method	Data	Units
	SIPE Evaluation	Natick/	NA	analyze ATD program	Recommendation of items to go to 6.3b
		Contract	NA	SIPE capabilities	Recommendation of items to go to 6.3b
	SIPE decision	-	NA	capability to be integrated	Approval of items to go to 6.3b
	Making		NA	into TEISS	-

APPENDIX B.

EVALUATION PLAN

EVALUATION PLAN
FOR THE
SOLDIER INTEGRATED PROTECTIVE ENSEMBLE
(SIPE)
ADVANCED TECHNOLOGY TRANSITION DEMONSTRATION
(ATTD)

JOHN A. O'KEEFE IV

5 DECEMBER 1991

CONCEPTS ANALYSIS DIVISION
ADVANCED SYSTEMS DIRECTORATE

PREFACE

This Evaluation Plan (EP) is designed to establish the parameters and guidance to be used in the evaluation of the Soldier Integrated Protective Ensemble (SIPE) Advanced Technology Transition Demonstration (ATTD). The EP outlines the evaluation in terms of exit criteria and the measures that will be used to judge whether these exit criteria have been met. This document will be revised/updated as required.

1.0 INTRODUCTION AND BACKGROUND

1.1 Purpose and Scope

a. Purpose. This document provides guidance for the evaluation and analysis of the SIPE ATTD results, including the results of the technical assessment, the human factors assessment, the operational demonstration, and the modeling and simulation. Evaluation as used in this document refers to the determination of the value and or merit that the capabilities and technologies demonstrated in the SIPE ATTD may have for future Soldier Systems.

b. Scope. This Evaluation Plan (EP) contains background information, evaluation concept and conditions, issues to be evaluated, major milestones, points of contact and references.

1.2 SIPE Program Background and History.

a. During fiscal year 1990 the Department of the Army initiated the Soldier Integrated Protective Ensemble (SIPE) Advanced Technology Transition Demonstration (ATTD). The SIPE ATTD is a 6.3a technology base demonstration of the capabilities that a systems approach and integration of state-of-the-art technologies can provide for improved operational effectiveness of the individual dismounted infantry soldier. It is a fully coordinated effort between the materiel developers (US Army Materiel Command) and the user (Training and Doctrine Command (TRADOC) - US Army Infantry School (USAIS)). The lead organization for managing and implementing this effort is the US Army Natick Research, Development and Engineering (RD&E) Center. The demonstration will lead to clear definition of requirements for The Enhanced Integrated Soldier System (TEISS). SIPE also serves as a means of exploring new operational concepts and is the first programmatic attempt to execute the philosophy of the Soldier Modernization Plan. TEISS is the Block I Soldier System to be fielded about fiscal year 2000 as delineated in the Soldier Modernization Plan.

b. The thrust of the SIPE ATTD is for the ground soldier, although the multitude of diverse technologies to be demonstrated have broad-reaching application for all soldiers. The ATTD will demonstrate a modular head-to-toe individual fighting system for the ground soldier which will sustain combat effectiveness while providing balanced protection against multiple hazards. As the cornerstone of soldier system research and development, the purpose of the SIPE ATTD is to draw upon the technological advances and achievements in several areas of the Army's Technology Base.

c. In order to accomplish this the demonstration will also establish a baseline of performance for the Soldier System. The ATTD will highlight the needs that technology must satisfy. Specifically, the goals of the SIPE ATTD are to demonstrate:

(1) Enhanced combat effectiveness through-
- Command and Control enhancements
- Improved soldier-to-soldier communications
- Improved soldier-weapons interface
- Reduction in total weight/bulk

(2) Improved survivability through-
- Multiple threat protection
- Maintenance of thermal equilibrium

d. The SIPE ATTD integrated technologies are those developed within the research and development community at the US Army Natick Research, Development and Engineering Center (Natick), the US Army Armament RD&E Center (ARDEC), the US Army Belvoir RD&E Center (BRDEC), the US Army Chemical RD&E Center (CRDEC), the US Army Communications RD&E Center, the Communications Electronics Command (CECOM) Center for Night Vision and Electro-Optics (C2NVEO), and the US Army Electronics Technology and Devices Laboratory (ETDL). Together, with the support of key US Army Laboratory Command (LABCOM) elements, including the US Army Human Engineering Laboratory (HEL), the Harry Diamond Laboratory (HDL), the US Army Medical Research and Development Command (MRDC) and the Army Research Institute (ARI), the integration and demonstration of advanced technologies for the soldier system will be accomplished using state-of-the-art technologies to help define the specific requirements which will allow the US Army to effectively implement the Airland - Battle Future (ALB-F) Doctrine. This effort will also provide for transition of these technologies into follow-on full scale development efforts which will take our soldiers into the next century.

1.4 Threat Description.

a. The U.S. soldier will be employed throughout the entire depth of future battlefields. The soldier, as well as his subsystems, individual weapons, and singular items of equipment, will not only be operational at the actual points of battle, but also will be employed throughout both friendly and threat rear areas. As key components of a combat system centered around the individual soldier, they are integral to each other. Therefore, loss of the soldier, for any reason, will result in loss of the subsystems operational capability. Both are also degraded by current weapon systems, extreme environmental and weather conditions, protective measures, and normal battlefield conditions that result in breakage and wear. The baseline threat document for the Soldier Modernization Plan is the Individual Soldier Clothing and Equipment System Threat Assessment Report (STAR) (S), dated February 1990. The STAR is an umbrella document categorized by threat operational and functional capabilities, and is specifically designed to support the concept based requirements system (CBRS) for individual soldier subsystems. The assessment of each threat operational capability is subdivided into limited and general war environments. Defense Intelligence Agency (DIA)/US Army Foreign Science and Technology Center (FSTC) have recently been requested to perform an Integrated Hazard Analysis for the individual soldier. The results of this analysis will provide a Threat Hazard Assessment that not only examines threat hazards within specific domains such as ballistic, chemical, nuclear, and biological, but also examines the synergistic effects resulting from multiple domain hazards.

b. The most technologically advanced threat to the soldier occurs in general war and operational continuum. In this environment degradation and destruction to infantry systems will result from direct and residual combat action. Fragmentation from artillery and mortar fires, mines, aerial delivered munitions; and to a lesser degree, surface to surface missiles represent the major threat throughout the depth of the battlefield. Along the fronts and in rear areas where threat forces are inserted/engaged, direct combat action against enemy armor, antitank, and infantry weapon systems will pose a major hazard. Degradation of systems will result from threat use of directed energy weapons, flame/incendiary, electromagnetic weapons/munitions, biological and chemical agents, and obscurants.

c. The potential for limited war requires that combat systems be capable of effective and sustained operations in all types of terrain and all climatic conditions, against all known and projected weapon systems. Ballistic fragments remain the primary threat to the individual soldier. Threat systems encountered will vary from the most modern to those developed by third world nations. The potential for use of offensive chemical and biological agents, and nuclear weapons will increase as more nations obtain these technologies.

d. Fragments from mines, grenades, booby traps, homemade explosives, artillery, mortars, tube-launched rockets, and rocket propelled grenades will be the primary threat in limited war. Direct fire from small arms, machine guns, and crew served weapons will be a major threat.

1.5 SIPE Concept Description.

a. The purpose of the SIPE ATTD is to demonstrate the capabilities that a systems approach and integration of state-of-the-art technologies can provide for the individual dismounted infantry soldier. The SIPE ATTD will demonstrate a modular head-to-toe individual fighting system for the ground soldier which will enhance combat effectiveness while providing balanced protection against multiple hazards.

b. The technical assessments will be conducted by Army Materiel Command (AMC) organizations and the U.S. Army Research Institute of Environmental Medicine (USARIEM). The human factors assessment will be conducted by Natick and U.S. Army Human Engineering Laboratory (HEL). The operational demonstration will be executed by the USA TEXCOM Infantry Directorate, conducted at Fort Benning, GA and the operational evaluation will be done by the U.S. Army Infantry School (USAIS). The modeling and simulation will be conducted by the Institute for Defense Analyses (IDA) and Natick.

c. The analysis and evaluation will be conducted by using a building block approach, first examining the performance of subsystems and system against exit criteria, then the performance of the entire system, and lastly, the effects of SIPE has on individual and unit performance. In order to accomplish the evaluation of the results of the ATTD, the results of the technical assessment, the human factors assessment, the operational demonstration, the operational demonstration assessment, and the modeling and simulation will be analyzed. These results will first be compared against the approved exit criteria (appendix E). This comparison will determine whether the demonstrated system has achieved the ATTD System Exit Criteria and Subsystem ATTD minimums.

d. The ATTD will establish the baseline of Soldier System performance which will serve as a basis for comparison to standard equipped soldiers. A preliminary set of Soldier System performance measures are listed in appendix G. These measures of performance were developed jointly by USAIS and the Army SIPE Manager by developing Operational Issues and Criteria from the SIPE Exit Criteria (appendix E). Members of the Behavioral Science Division, Soldier Science Directorate, Natick then translated the Operational Issues and Criteria from a mix of human and material performance measures into human performance measures.

e. The technical assessment will concentrate on technical performance of SIPE subsystems and components. The human factors assessment will examine the soldier/SIPE, soldier/subsystem, subsystem/subsystem, and subsystem/component interactions. The operational demonstration, including extensive training, will examine Baseline and SIPE equipped squads in a series of short tactical field exercises and more focused performance assessments such as weapons qualification ranges, land navigation courses, and target identification ranges. A description of the equipment that will be used by the Baseline soldiers during the operational assessment is provided at appendix H. The field demonstration will allow the exploitation of tactical enhancements afforded by SIPE. The modeling and simulation will evaluate the SIPE and baseline equipped soldiers in force-on-force situations and against threats and hazards that can not be reasonably recreated in a peacetime field exercise.

f. The impact of the capabilities demonstrated in the SIPE ATTD will be assessed by using an Analytical Hierarchy Process (AHP). The hierarchy will be constructed by using USAIS approved Soldier Oriented ATTD Exit Criteria to Support Mission Accomplishment of "Lethality", "Command and Control", "Survivability", "Sustainability", "Mobility", and "Training" and the issues and criteria developed by the U.S. Army Infantry School in conjunction with the Army SIPE Manager. The ultimate question that the evaluation will seek to answer is how the demonstrated capabilities affect the soldier/unit's ability to shoot, move, communicate, and survive on the future battlefield.

2.0 SYSTEM EVALUATION OBJECTIVES AND APPROACH

2.1 System Evaluation Objectives

a. The objectives of the system evaluation are to: 1) assess the impact that the capabilities demonstrated by SIPE will have on the soldier/unit's ability to accomplish assigned tasks/missions across the full spectrum of conflict; and 2) to determine whether the ATTD Exit Criteria were met. The ultimate question that the evaluation will seek to answer is how do the demonstrated capabilities affect the soldier/unit's ability to shoot, move, communicate, and survive on the future battlefield.

b. As pointed out by Dr. Refik Soyer, in "Evaluation of Soldier Integrated Protective Ensembles Using Analytic Hierarchy Process",[6] when making an evaluation, such as that required for the SIPE system, some of the evaluation factors are quantitative and some of the factors are qualitative. A difficulty that then evolves is to use a technique to combine these two different type of value systems in a formal manner using a meaningful scale. Soyer proposed the use the Analytic Hierarchy Process developed by Saaty in the 1970's.[6]

2.2 System Evaluation Tools

a. It is important to note that the SIPE ATTD system evaluation, like any multi-attribute evaluation problem, has some factors which are quantitative and some factors which are qualitative. The common difficulties in making such evaluations are: the human cognitive limitations in dealing with multiple factors, the need to combine different type of scales and the lack of any meaningful scale for the qualitative attributes. Evaluation of the SIPE ATTD will involve quantitative information in the form of the results of technical assessment, human factors assessment, operational assessment, and simulation/modeling as well as qualitative information from the human factors assessment, operational assessment and simulation/modeling. Thus the selected evaluation methodology should allow combining quantitative and qualitative data in a formal manner and it should have a meaningful scale that allows description of intensity of preferences. Furthermore, the methodology should allow incorporation of experts' input with respect to importance of different material characteristics and performance attributes in a formal manner.

b. The evaluation of the SIPE ATTD necessitates use of a multi-attribute evaluation technique such as the Analytic Hierarchy Process (AHP) with a theoretically sound foundation. AHP, developed by Dr. Thomas L. Saaty in the 1970's, is an approach to multi-criteria decision making. AHP is one of the main competing views in decision analysis which is widely used for multi-attribute evaluation and choice.

c. AHP enables decision makers to structure a complex problem in the form of a hierarchy. Each factor and alternative can be identified and evaluated with respect to other related factors. Judgments are solicited from decision makers/experts about each facet of the decision problem. The methodology goes beyond conventional decision analysis techniques by not requiring numerical guesses. Subjective judgments on aspects of a problem for which no scale of measurement exists are accommodated. The judgments are used in deriving ratio scale priorities for the decision criteria and alternatives.

d. AHP is based upon the principles of decomposition, comparative judgments and synthesis of priorities. The first stage in AHP is to decompose the overall decision problem into a hierarchy. The next step is to evaluate each element of the problem. An AHP evaluation is based upon the decision maker's or experts' judgments about the relative preferences for the alternatives with respect to each (sub)criterion, about the relative importance of the subcriteria with respect to each criterion, and about the relative importance of the criteria in terms of their contribution to the overall goal. In other words, each node of the hierarchy is evaluated against each of its peers in relation to its parent node; these comparisons are called pairwise comparisons. Judgments can be based upon hard data as well as decision

maker's/expert's knowledge and experience.

e. Pairwise comparisons are the basic measurement mode employed by the AHP. Another aspect of the AHP pairwise comparison process is that a nine-point scale is used in order to evaluate the preferences for each pair of items. Although other methods of scaling and rating could be used with AHP, research and experience has shown that the 9 point scale offers reasonably good discrimination. The fundamental scale of AHP is shown in Table 1. The decision maker/expert can use the scale to make either verbal or numerical comparisons.

f. When making comparisons in a social, psychological, or political context, it is usually more appropriate to make verbal comparisons. When comparing economic or other more appropriate to make verbal comparisons. When comparing economic or other measurable factors, numerical comparisons may be more appropriate. Subjective judgments on aspects of a problem for which no scale of measurement exists are easily accommodated using this scale. Past experience shows that use of words is ideal especially for fuzzy situations.

Table A-1
Pairwise Comparison Scale for AHP

Verbal Judgment	Numerical Judgment
Extremely preferred	9
Very strongly to extremely preferred	8
Very strongly preferred	7
Strongly to very strongly preferred	6
Strongly preferred	5
Moderately to strongly preferred	4
Moderately preferred	3
Equally to moderately preferred	2
Equally preferred	1

g. AHP uses the fundamental scale to accommodate pairwise comparisons either verbally or numerically. Pairwise comparisons of the elements at each level of an AHP model are made in terms of either:

> Importance - when comparing criteria, players, or segments with respect to their relative importance.
>
> Preference - when comparing the preference of alternatives with respect to their specific qualities relative to a criterion.
>
> Likelihood - when comparing uncertain events or scenarios with respect to the probability of their occurrence.

h. Once the comparisons are completed and the matrix of pairwise comparisons has been developed at a particular level of the hierarchy, the "priorities" can be derived for each of the elements being compared. The judgments are used in deriving relative priorities for the decision criteria, subcriteria and the alternatives. This is accomplished by calculating eigenvalues and eigenvectors of the pairwise comparison matrices. This methodology has been shown to provide accurate and robust results. It is important to note that the derived priorities are ratio scale numbers. Priorities provide an abstract unit valid across all scales. A priority scale based on preference is the AHP's way to uniformize non-unique scales in order to combine multiple criteria, In AHP judgments are used to express preferences and their intensity. From these preferences one scale of relative priorities or strengths of preferences are derived.

i. An important outcome of the pairwise comparison process is the redundant information. When making judgments in the form of pairwise comparisons, the relative preference (or importance) of N factors can be derived by making only (N-1) judgments. For example, if we compare the relative importance of three factors A, B, and C, and if we judge that A is three more important than B and A is six times more important than C, we can conclude that B is two times as important as C. However, each of the two judgments might contain some inaccuracy and to minimize inaccuracy one can make additional judgments about all possible pairs of N(N-1)/2 of factors instead of the minimum of (N-1) judgments. Such redundancy reduces the effects of errors in judgments by "averaging" and therefore improves accuracy.

j. The AHP methodology also develops a measure of inconsistency. Unlike some other approaches to multi-criteria decision analysis, the theory of AHP does not require perfect consistency, but provides a measure of how much inconsistency there is in each set of judgments. This measure of inconsistency is an important by-product of the process of deriving priorities based upon pairwise comparisons. It is useful in identifying possible errors in expressing judgments as well as real world inconsistencies. In AHP consistency implies that the actual intensity, in which the preference is expressed, transits through the sequence of factors in comparison. Such a definition of consistency is stronger than that of the transitivity of the comparisons. AHP automatically computes an inconsistency ratio for each set of pairwise comparisons made as well as for the overall model. The ratio is based on simulations of random judgments. An inconsistency ratio of about 10% or less is usually considered "acceptable", but the particular circumstances may warrant the acceptance of a higher value. As a rule of thumb, if the inconsistency ratio is greater than 10%, one should investigate and try to ascertain the possible cause(s) of the inconsistency. Inconsistency can result from an improper conceptualization of the hierarchy, lack of information, a mental lapse, or clerical errors. If each of the possible causes discussed above is eliminated, then it is reasonable to proceed even though the inconsistency ratio is slightly greater than 10% rule of thumb value.

k. Once judgments have been entered for each part of the model, the information is synthesized to achieve an overall preference ranking of the alternatives. The synthesis produces a report which ranks the alternatives in relation to the overall goal. The AHP output presents each of the components that contributes to the overall priorities so that the decision maker can assess the results, implementing them as they seem appropriate or refining the model to reflect additional insights that have been acquired.

l. AHP allows the examination of the solution with some interesting "what if" or sensitivity analyses. Sensitivity analysis assists decision makers with questions they may have about the relative importance of information, or when they want to know how possible changes in information will affect results. Sensitivity analysis is also conducted in order to gain a better understanding of a decision analysis AHP provides the decision maker with three types of sensitivity analyses.

m. A sensitivity analysis can be performed to see how sensitive the alternatives are to changes in the importance of the criteria, players or scenarios. This type of analysis shows the "gradient sensitivity" of alternative priorities with respect to changes in a particular criterion.

n. AHP can be effectively used to analyze complex multi-criteria evaluation and choice problems such as involving both quantitative and qualitative criteria. What makes AHP effective is that (1) the judgments can be made graphically, numerically, or verbally; since numeric guesses are not required, subjective judgments (which are inevitable in any evaluation problem) can be accommodated, and (2) the mathematical analysis performed on the judgments produces results that are accurate, robust, which includes a measure of consistency of the judgments.

o. Another feature of AHP that makes it attractive for multi-attribute evaluation is that AHP is well suited to group decision making (evaluation). In group decision making with common objectives AHP allows use of several approaches. AHP provides a framework for focused discussion and exchange

of ideas and information and makes it easy for the group to arrive at a consensus on judgments. If a consensus can not be reached on particular set particular set of judgments, voting methods can easily be used in AHP. As an alternative to voting, geometric average of judgments can be computed using AHP. If decision makers differ strongly on their judgments, they can make judgments separately. This can be done in two ways: either group member makes their judgments in separate models and the priorities from each of these models can be averaged or the group members can be added as a level to the model and their evaluations can be synthesized. In so doing, the relative importance of the decision makers can be determined using one of the following approaches:

- equal player importance

- judgments about player importance

- subsidiary multi-criteria model for player importance.

p. In order to accomplish this evaluation, it is first necessary to identify those abilities/functions which are necessary to accomplish the ground infantry's assigned tasks/mission and then to map those abilities/functions against the required capabilities of the soldier. Table 2 provides such a mapping of abilities/functions versus capabilities. The capabilities are based upon those discussed in the Soldier Modernization Plan plus Training. Training was added to the list of required capabilities by the Infantry School.[4]

q. It is also necessary to keep in mind that these capabilities are often inter-dependent. Table 3 maps some of these inter-dependencies.

r. The weighting or importance given to each of the capabilities and abilities/functions will change based upon context in which the future battle is viewed, the composition of the unit, and the assigned mission of the individual/unit. In order to establish the proper weighting for each of the capabilities and abilities/functions, a combination of a pair-wise comparisons and the result of high resolution simulation will be used. The pair-wise comparisons will be conducted by Natick during the second quarter of fiscal year 92 to insure that its results are available prior to the operational assessment. The pair-wise comparisons will address the effects of differences in mission, level of conflict intensity, and unit composition. The tentative audiance for the pair-wise comparison is members of the USAIS, US Army Sergeant Majors Accademy and the US Army Research Institute.

s. The high resolution simulation will be conducted by IDA and Natick using the Janus, Security Exercise Evaluation Simulation (SEES) and Urban Combat Computer Assisted Training System (UCCATS) simulations. These models were developed by the Lawerance Livermore Laboratory.

t. The Janus simulation models combat systems, the battlefield environment, and each system's interation with other systems and their environment. Janus is an event-driven simulation that models fighting systems as entities. Entity characteristics include descriptions of weapons carried, weapon capabilities, movement speeds and how they are attenuated by terain effects, accountability of ammunition and fuel, crew perfromance, sensor data describing how the battlefield is observed, as well as supply/resupply performace data. Janus has been validated/verified using a number of field exercises to include National Warfare Training Center Exercise.

u. The SEES model is an evolutionary development from the Janus Conflict Model which will simulate the intrusion, safeguard system performance, and individual close range combat between two oposing forces. Combat is simulated in a highly detailed and finely resolved environment, includiong the interiors of buildings. SEES provides a broder baseline in the evaluation of security force on force perfromance test exercises, allow ratings to be based upon a mixture of simulations and actual field tests. Department of Energy has validated and Verified SEES using actual field Nuclear weapon sotorage site security exercises.

Table A-2. Capability Map

	Capabilities					
Ability/Function	Leth	C2	Surv	Sust	Mobil	Train
Ability to acquire enemy targets/info	X	*	X			X
Ability to locate/position targets	X	*	X		X	X
Ability to engage enemy	*	X	X	X		X
Ability to incapacitate/destroy targets	*	X	X	X		X
Internal squad communications	X	*	X			X
External squad communications	X	*	X			X
Ability to avoid detection	X		*			X
Probability of Hit/Shot	*	X	X	X		X
Ability to disperse		X	*		X	X
Probability of Survival When Hit			*	X		
Level of ballistic protection			*		X	
Level of chemical protection			*		X	X
Level of Heat Stress			X	*		X
Soldiers Load				X	*	
Fit				X	*	
Physiological/psychological status	X		X		X	*

* = Primary Capability affected by or provided by the ability or function

Table A-3. Map of Capability Inter-Dependencies

	Capabilities					
Capabilities	Leth	C2	Surv	Sust	Mobil	Train
Lethality	-	X	X	X		X
Command & Control		X	-	X		X	X
Survivability	X	X	-			X
Sustainability	X	X	X	-		
Mobility	X	X	X		-	X
Training	X	X	X		X	-

2.3 System Evaluation Approach

a. Based upon Dr. Soyer's recommendation, an analytic hierarchy has been developed using the mapping of capabilities versus abilities/functions. This analytical hierarchy is shown in figure 1.

b. The results of the pair-wise comparison and the simulation will be used to develop the weighting factors for the analytic hierarchies for high intensity conflict (HIC), medium intensity conflict (MIC) and low intensity conflict (LIC) future battlefields. This means that when NBC and Non-NBC variations are considered a minimum of six sets of weightings will be developed. Weighting factors will be developed for both the capabilities and the functions which are arrayed beneath each capability. The results of the technical, human factors, and operational assessments, along with modeling results for both the SIPE and Baseline Equipped soldiers/units will then be input into the SIPE System Analytic Hierarchy. This will produce a comparative measure of merit for both the SIPE and Baseline systems/units.

c. Sensitivity analysis will also be accomplished using the SIPE System Analytic Hierarchy.

This will allow the identification of those factors/capabilities having the greatest impact on the relative order of merit for both systems.

d. The Integrated Unit and Soldier Performance System, being developed by Natick under contract, will be used in conjunction with the SIPE System Analytic Hierarchy to examine the effects of the demonstrated capabilities on unit performance.

e. The analytic hierarchy, sensitivity analysis, UCCATS simulation and the Integrated Unit and Soldier Performance model will be used to identify those capabilities which contribute to the soldier/unit's ability to shoot, move, communicate, and survive on the future battlefield to recommend transfer into Full Scale Development. Those technologies which, while demonstrating potential for future contribution, fail to demonstrate a level of maturity necessary to progress into Full Scale Development, will be identified for further tech base research. The measures of performance and Soldier System Baseline developed in support of the SIPE ATTD will be documented.

f. The SIPE System Evaluation Report will include the results of all technical assessment, human factors assessment, operational assessments and modeling/simulation as annexes, thereby providing a single source of information about performance from components, subsystems, systems and units.

2.4 Review of SIPE System Evaluation Report

a. The SIPE System Evaluation Report will be furnished to AMSAA after completion for independent review. AMSAA will review the report to insure that all of the required exit criteria have been addressed and that the reports conclusions are support by the presented information.

b. At the same time as the AMSAA review, the evaluation report will be provided to the TRADOC System Manager (TSM) Soldier. The TSM Soldier will review the report to insure that it provides the information necessary to support future decisions related to the application of ATTD capabilities to future soldier systems.

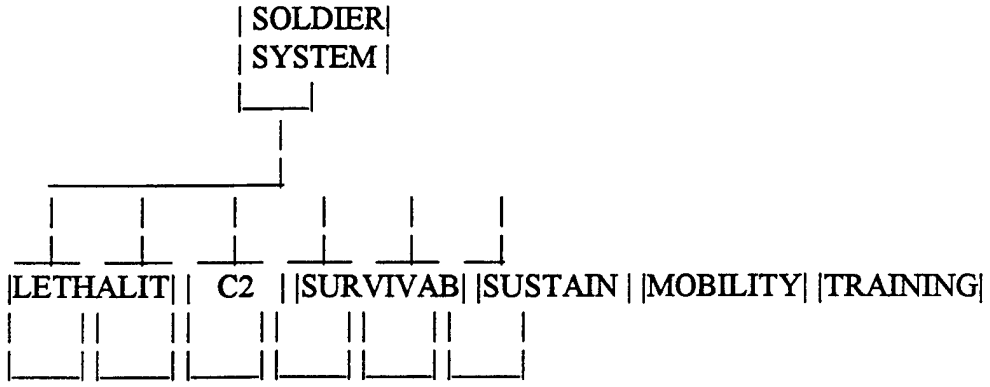
c. Figure 2 provides a graphical representation of the evaluation and decision process for the SIPE ATTD.

2.5 Use of SIPE System Evaluation

a. The SIPE System Evaluation Report will be provided to the Commandant of the US Army Infantry School to support decisions as to what capabilities should be included in TEISS and what capabilities should be included in future systems. This will provide the impetus to initiate the requirements documentation for the scheduled fiscal year '94 commencement of the TEISS 6.3b program.

b. The SIPE System Evaluation Report will be provided to the US Army Materiel Command Tech Base Executive Steering Committee (TBESC) to identify those technologies which require additional research prior to transition into full scale development. The report will also serve to identify those technologies for which continued investment is not currently justified.

Figure A-1. SIPE System Analytic Hierarchy



C2 --- COMMAND AND CONTROL CAPABILITY
LETHALIT --- LETHALITY CAPABILITY
MOBILITY --- MOBILITY CAPABILITY
SURVIVAB --- SURVIVABILITY CAPABILITY
SUSTAIN --- SUSTAINABILITY CAPABILITY
TRAINING --- TRAINING CAPABILITY

APPENDICES BIBLIOGRAPHY

1. Fitzgerald, Carol J., Patrick R. Snow, CPT Michael F. Nugent, Soldier Integrated Protective Ensemble (SIPE) Advanced Technology Transition Demonstration (ATTD) Briefing, 6 August 1991, U.S. Army Natick RD&E Center, Natick, MA.

2. Fitzgerald, Carol J., Soldier Integrated Protective Ensemble (SIPE) Advanced Technology Transition Demonstration (ATTD) Technical Review and Risk Assessment, 4-5 September 1991, U.S. Army Natick RD&E Center, Natick, MA.

3. ATSH-CDM-C, Revised Exit Criteria for the Soldier Integrated Protective Ensemble Advanced Technology Transition Demonstration -- Decision Paper, 7 October 1991, U.S. Army Infantry School, Ft. Benning, GA.

4. ATSH-CDT, Draft Memorandum, Operational Issues and Scenario Events/Tasks for the Soldier Integrated Protective Ensemble Customer Test, 4 October 1991, U.S. Army Infantry School, Ft. Benning, GA.

5. ATSH-CDC-C, Soldier Modernization Plan, 22 March 1991, Ft. Benning, GA.

6. Soyer, Refik, Evaluation of Soldier Integrated Protective Ensembles Using Analytical Hierarchy Process, 19 April 1991, The George Washington University School of Business and Public Management, Washington, DC.

7. Fitzgerald, Carol J., Patrick R. Snow, CPT Michael F. Nugent, Soldier Integrated Protective Ensemble (SIPE) Advanced Technology Transition Demonstration (ATTD) Technology Development Plan, November 1990, Natick, MA

8. O'Keefe, John A., Materiel Support To Low Intensity Conflicts, US Army Natick Research, Development and Engineering Center, July 1989, Natick, MA.

Appendix B.
Acronyms

AMC	Army Materiel Command
ARDEC	US Army Armament Research, Development and Engineering Center
AMSAA	US Army Materiel Systems Analysis Activity
ARI	Army Research Institute
ATTD	Advanced Technology Transition Demonstration
BRDEC	US Army Belvoir Research, Development and Engineering Center
C2	Command and Control
C2NVEO	US Army Communications and Electronics Command Center for Night Vision and Electro-Optics
C4I	Command, Control, Communication, Computer and Intelligence
CBRS	Concept Based Requirements System
CECOM	US Army Communications Electronics Command
CRDEC	US Army Chemical Research, Development and Engineering Center
EP	Evaluation Plan
ETDL	Electronics Technology and Devices Laboratory
HDL	US Army Harry Diamond Laboratory
HEL	US Army Human Engineering Laboratory
HIC	High Intensity Conflict
IDA	Institute for Defense Analyses
LABCOM	US Army Laboratory Command
LIC	Low Intensity Conflict
MIC	Mid Intensity Conflict
MRDC	US Army Medical Research and Development Command
NATICK	US Army Natick Research, Development and Engineering Center
PM-CIE	Program Manager - Clothing and Individual Equipment
RDEC	Research, Development and Engineering Center
SIPE	Soldier Integrated Protective Ensemble
STAR	System Threat Assessment Report
TEISS	The Enhanced Integrated Soldier System
TRADOC	Training and Doctrine Command
TSM Soldier	TRADOC System Manager Soldier
USAIS	US Army Infantry School
USARIEM	US Army Research Institute of Environmental Medicine

Appendix B.
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Appendix C.
Milestones

	Completion Date
Initial Draft SIPE System Evaluation Plan	15 Oct 91
Draft SIPE System Evaluation Plan coordinated with USAIS, AMSAA, HEL	15 Nov 91
Final Draft SIPE System Evaluation Plan Coordination	1 Dec 91
Receipt of all comments on Final Draft SIPE System Evaluation Plan	31 Dec 91
Final SIPE System Evaluation Plan incorporated into SIPE ATTD Technology Development Plan	15 Jan 92
Ability/Function Capability Pair-Wise Comparison	30 Apr 92
Receipt of Technical Assessment Reports	Sep 92
Receipt of Human Factors Assessment Reports	Sep 92
Receipt of Technical Assessment Reports	Oct 92
SIPE Operational Demonstration	Sep/Nov 92
Receipt Human Factors Assessment Reports	Nov 92
Receipt of Operational Assessment Report from USAIS	Feb/Apr 93
Receipt of Simulation and Modeling Reports	Jan 93
SIPE System Evaluation Report	Apr 93

Appendix D
SIPE Phase I Subsystems and Modules Description

A. SIPE is composed of four primary subsystems: the Integrated Headgear Subsystem; the Advanced Clothing Subsystem; the Microclimate Conditioning/Power Subsystem; and the Soldier Computer Subsystem. The four subsystems are comprised of technologies and components which are contained in eight modules. The eight modules divide the technologies required to support the three subsystems along more traditional materiel development discipline lines. Each module is comprised of components of the system required to provide an operational capability, regardless of which subsystem to which they belong. The eight modules are:

Clothing and Individual Equipment Module
Ballistic Module
Command, Control, Communication, Computer and Intelligence Module (C4I)
Electro-Optics Module
Chemical/Biological Module
Microclimate Conditioning/Power Module
Load Bearing Module
Weapons Module

B. The Integrated Headgear Subsystem (IHS) is a modularly designed integrated protective system. The subsystem consists of 2 primary components, (IHS Ballistic Shall and Back-Up Power Supply), and 5 modular subcomponents (Ballistic Facepiece, Communications, Electro-Optics, Suspension/Liner, and Ballistic Neck Protector). Based on specialized mission requirements, the 5 subcomponents are interchangeable within the ballistic shell, and are also capable of operating with any combination of subcomponents or all subcomponents together, as required or mandated by the mission requirements and/or soldier responsibilities. The IHS subsystem affords the user the following performance/protection criteria; complete head, eyes, face, and neck ballistic protection, soldier-to-soldier short and long range communications along with state-of-the-art aural protection, counter surveillance, state-of-the-art protection against nuclear, biological and chemical (NBC) threats of the modern battlefield, a remote viewing device for the weapon's fire control device, day and night vision enhancement, and laser eye protection. The IHS Ballistic Shell and modular facepiece serve as a mounting base for all subcomponents.

1. Ballistic Shell Component (BCS). The BCS is an Open Face Helmet (OFH) ballistic shell that is constructed of a fabric based composite. The shell has a configuration similar to the current PASGT helmet and weighs approximately 3 pounds (1300 grams). This shell is the mounting base for the five IHS modular subcomponents. The subcomponents are: the Ballistic Facepiece Subcomponent (BFS), the Communications Subcomponent (COMS), the Electro-Optics Subcomponent (EOS), and the Suspension/Liner Subcomponent (SLS).

a. Ballistic Facepiece Subcomponent (BFS): The BFS is a quick connect/disconnect modular ballistic subcomponent that will house the following parts and/or pieces of parts. They include; the Ballistic Transparency, Laser Eye Protection, Respiratory Protective Device (i.e. nose cup, inlet valve, exhalation port, etc.), Hydration Liquid Nutrient (HLN) transport line and mouthpiece, ambient sound listening microphones with wiring, external speaker with wiring and EOS Optics Assembly.

b. Communications Subcomponent (COMS): The COMS includes a headstock that fits tightly over the wearers head. Mounted to this headstock is a bone conduction microphone on the forehead, 2 electronic earplugs, one for each ear and a pre-amp and connector for the interface to the radio.

c. Electro-Optics Subcomponents (EOS): The EOS includes a visual enhancement assembly (dorsal pod) and a display assembly.

d. Suspension Liner Subcomponent (SLS): The SLS includes a cradle suspension, an air bladder at the nape of the neck with a pump and a 4-point suspension system.

2. Power Supply Component (PSC). The PSC consists of 2 subcomponents: the Main Power Supply Interface and the Backup Power Supply.

a. Main Power Interface is a quick connect/disconnect interface that will relay the power from the power supply (engine or batteries) to the headgear, EOS and COMS subcomponents.

b. The Back-Up Power Supply is a battery pack that will be housed on the Load Bearing Component of the ACS.

3. The Integrated Helmet Subsystem encompasses all, or portions of, the following modules/module components:

- Ballistic Module
  - Ballistic Shell
  - Ballistic Transparency
  - Laser Insert
  - Ballistic Face Piece
- C4I Module
  - Radio/Comms Module
  - Non-NBC Listening w/Aural Protection
  - Non-NBC Speaking
  - NBC-Listening w/ Aural Protection
  - NBC Speaking Aural Protection
  - Augmented Hearing
  - Helmet Control Unit
  - IHS Electronics Pack
- Electro-Optic Module
  - Electro-Optics Vision Enhancements
    - Image Intensifier
    - CCD Camera
    - Flat Panel LCD
    - Thermal Imager
  - Display Optics
    - Beam Splitter Optics Lens
    - EOS Control Module
    - Back-up Power
- Chemical/Biological Module
  - Respiratory Protective Device
  - Hydration/Liquid Nutrient
- Weapon Module

C. The Microclimate Conditioning/Power Subsystem (MCC/PS) has two primary functions: reduce heat stress and provide a source of power to the soldier.

1. The MCC/PS will reduce heat stress by providing ambient air inside the suit and helmet of the SIPE soldier. Ambient air was chosen from several Microclimate Conditioning (MCC) technologies as a low risk approach. This type of MCC has proven to be very effective in a temperate environment.

Ambient air's primary mechanism for heat removal is evaporation. The perspiration on the skin is evaporated by the flow of ambient air over the skin.

2. The MCC/PS is also designed to be the primary power source for individual soldier. Not only will it power the MCC unit, but it will also power the electrical components of the IHS.

3. The MCC/PS will consist of three main components: blower, filter, and power source. The blower component is designed to provide 18 cfm of air at 8" water column of back pressure. It is powered by a 24 VDC source and weighs 4 pounds. The noise output is 70 dBa or less at one meter when operating with no back pressure. The filter component will filter the ambient air before it is drawn into the blower. The filter will process 18 cfm for CB agents. The pressure drop through the filter will be approximately 4.0" water column or less. The filter case will be constructed of lightweight materials to minimize the weight of the filter. It should weigh less than 5.0 lbs. The openings in the filter must be protected so as to prevent interference by environmental elements. Filter design was performed by the US Army Chemical Research, Development and Engineering Center (CRDEC), Aberdeen Proving Ground, Maryland. The power component of the MCC/PS must supply power to the MCC/PS blower component and to the electronic subcomponents of the IHS. This requires 100 watts at 24 VDC. The power component must be able to supply power for six continuous hours without any re-supply. For the SIPE program, two power components will be demonstrated: a Stirling engine/generator set and a $LiSO^2$ battery. The Stirling engine/generator set will run on diesel fuel, provide 24 VDC, 100 watts, and be self-starting. It will also be orientation independent, weigh less than 14 lbs. dry, and provide more than six hours of operation without refueling. The requirements for the battery chosen are to provide 24 VDC and have a high power density.

4. Several secure and reliable mechanisms to provide a durable interface are required as outline below.

a. The blower will couple with the ACS. The ACS is providing the air distribution mechanism. The MCC/PS blower will provide air into this air distribution mechanism.

b. The blower will also provide air into an opening in the IHS. This will be breathing air in the oronasal cavity as well as air flow in the helmet to cool the face and electrical components. In order to provide air to both the IHS and ACS, a mechanism will be employed to split the air stream exiting the blower. A small portion of the stream (3 cfm) will be directed to the IHS, while the remaining 15 cfm will go to the ACS. This mechanism may be the standard Army Y-connector or a redesign of it.

c. The power component will provide power to the IHS. It must be capable of powering the image intensifier device, the HUD CRT, and communication devices.

d. The MCC/PS will be mounted to the Load Bearing Component (LBC) which is provided by the ACS. It will be considered a noncombat essential portion of the load. The subsystem must be able to quick-disconnect from the LBC. Hosing and wiring will be considered in the quick-disconnect design, as well as the three components of the subsystem.

5. The Microclimate Conditioning/Power Subsystem includes all or portion of the following modules/module components:

- Chemical/Biological Module
  - Air Distribution Garment
- Microclimate Conditioning/Power Module
  - Blower
  - Filter
  - Power Source

D. The Advanced Clothing Subsystem (ACS) is to improve the effectiveness of the soldier by providing balanced multiple threat protection in a modular, integrated head-to-toe clothing system. The system will allow for greater soldier mobility and operational effectiveness through its inherent design features, capability for mission tailoring and sizing/fit based upon the current US Army anthropometrics data base.

1. The ACS consists of eight subcomponents (listed as worn outer to inner in full-up configuration):

Load Bearing Component
Ballistic Protective Vest
Advanced Shell Garment Jacket & Trouser
Advanced Combat Uniform Jacket & Trouser
Chemical Vapor Undergarment
Active Cooling Vest
Waste Management System (PAD)
Handwear
Footwear

2. The Load Bearing Component (LBC) houses the MCC/PS, facilitates ammunition carrying capability and provides cargo (and miscellaneous equipment) carrying capability. The system is designed to compatibly interface with and augment the ballistic protective capability of the Ballistic Protective Vest by providing ballistic protection (fragmentation and flechette) in the shoulder harness and waist belt. The LBC allows for individual sizing, provides protection against visual detection and features a quick release capability, enabling the load to be streamlined when necessary.

3. The Ballistic Protective Vest (BPV) will provide fragmentation and flechette protection to the upper torso through state-of-art materials and configuration. The wrap around styled vest possesses some ammunition carrying capability, provides environmental and visual detection protection, and is compatible with all other ACS subcomponents. Adding the shoulder harness and waist belt of the LBC increases the area of coverage. The BPV is sized, fitted and designed to be worn over the Advanced Combat Uniform, and either over or under the Advanced Shell Garment Jacket/Trousers.

4. The Advanced Shell Garment (Jacket/Trouser) provides protection against environmental, flame and energy threats. By including a semi-permeable membrane in the shell fabric, the Advanced Shell Garment also provides protection against a liquid and aerosol chemical threat. The Advanced Shell Garment is worn over the Advanced Combat Uniform. Placement relative to the LBC and BPV is scenario dependent, yet garment design/sizing allows for the Advanced Shell Garment to be worn over or under these subcomponents. The clothing design allows for compatibility with all ACS subcomponents including a reliable (i.e. chemical protective) interface with the handwear and footwear subcomponents as well as the Integrated Headgear System.

5. The Advanced Combat Uniform (ACU) is the baseline uniform which provides protection against environmental, flame and energy threats. The design and objective closely follow the current Battle Dress Uniform (BDU). The ACU is sized/fitted to accommodate the Chemical Vapor Undergarment, the Active Cooling Vest and the Waste Management System.

6. The Chemical Vapor Undergarment is a two piece garment which provides protection against a chemical vapor threat through an activated carbon fabric. The undergarment is designed to provide a streamlined comfortable fit as well as provide maximum area of coverage.

7. The Active Cooling Vest is based upon the Army's Generation II Microclimatic Cooling Vest. The vest allows for 15 cfm (150 watts) of filtered air to be directed at the the torso. By incorporating improved spacer fabrics in a germent design, the vest will be functional yet low profile. The ACS clothing layers will be designed with the appropriate pass through to facilitate the ACV hoses and manifold.

8. Waste Management System (for disposal of liquid waste) will be based upon a unisex Personal Adsorptive Device (PAD) which is stored within the ACS. Constructed of a combination of a gel and highly absorptive material, the PAD may be accessed from its storage point, emplaced in the urogenital area and removed after use. It is envisioned that the PAD will resemble a sanitary napkin in size and configuration. The soiled PAD may either be removed or stored within the ACS.

9. The ACS handwear component will be a two glove system: an outer glove and an inner chemical protective glove. The outer glove will be of a knit construction, providing protection from flame, visual detection and energy threats. The palmar surface of the glove will be coated/treated to enhance grip. The chemical protective inner glove will be a two layer glove. The inner layer will provide vapor protection through an activated carbon knit fabric while the intermediate layer will provide liquid/aerosol protection via a semipermeable membrane. The membrane itself will gain durability by lamination to a jersey knit. The glove system will fully utilized the Flexor star glove pattern designed to enhance dexterity and fit. The glove system will provide for reliable interface with the Advanced Shell Garment jacket cuff.

10. The ACS footwear will consist of a lightweight combat boot and a chemical protective gaiter. The lightweight boot utilizes state-of-the-art materials and fabrication technologies (e.g. direct molded sole) to improve protection, fit and comfort. The gaiter is designed to fit over the lightweight combat boot, using a rubber band to attach the gaiter to the sole of the boot. The gaiter upper is constructed of a combination of materials layered to provide chemical protection, protection from energy threats, visual detection and flame. An elastic draw cord located at the gaiter upper edge will facilitate a positive interface with the Advanced Shell Garment trouser. The Advanced Shell Garment trousers will be worn over the gaiter to prohibit chemical run-off into the boot.

11. The Advanced Clothing Subsystem includes the following Soldier System modules/module components:

- Clothing and Individual Equipment Module
  - Advanced Combat Uniform
  - Advanced Shell Garment
  - Combat Handwear
  - Footwear
- Ballistic Module
  - Torso Armor
- Chemical/Biological Module
  - Chemical Vapor Undergarment
  - Air Distribution Garment
  - Waste Management
  - Handwear (Chemical)
  - Gaiter
- Load Bearing Module

E. The Soldier Computer Subsystem consists of a ruggedized personal computer module constructed of all off the self components. The major components of the Soldier Computer Subsystem are the 386SX central processing unit (CPU) with a 40 megabyte (mb) hard disk drive, case, computer cards, power supply, and software. The Soldier Computer is intended to be used with the SIPE Heads-Up-Display (HUD) located within the Integrated Headgear Subsystem (IHS) which will display all output from the computer. The computer will be controlled via keys located on the IHS Helmet Control Unit (HCU).

1. Soldier Computer Case. The computer case will house all soldier computer components. It will be constructed to protect the computer from shock, moisture, dust, etc.. The case will be large enough to fit six full size computer expansion cards, a 2 1/2 inch 40 mb hard drive, and the power source which will be a BA 5590 or BA 6590 battery. Standard connectors will be used to interface the computer with various auxiliary equipment. The current size of the case is 15.5 inches long, 9.5 inches high, 5.5 inches deep.

2. Computer Cards. The backbone of the soldier computer is various commercially available cards located within the computer case. The cards currently identified include the 386SX CPU, a PC based Global Positioning System (GPS) card, a serial input/output (I/O) card, a video capture card, and a data radio card. One blank expansion slot is available for expansion. The medical monitor card is interfaced with the soldier computer.

3. Power Supply. The power supply for the computer will be the BA 5590 or BA 6590 battery. The battery will be contained within the case and power all computer components.

4. Software. The software for the soldier computer will consist of menu-driven, simple, cursor controlled software enabling the soldier to easily perform various functions with the computer. Such functions include accessing the GPS system for accurate navigational information, using the video capture function to take "pictures" of battlefield situations, accessing the data radio card to transmit information and "pictures" to other individuals, and using a wide variety of preformatted reports such as Bridge Reports, Spot Reports, etc.. Two expert systems will also be available on the soldier computer. These systems are the Load Expert System and Foraging Expert System. All software will be controlled via keys located on the IHS HCU. These keys include the cursor keys (left, right, up, down), an enter key and an escape key.

Appendix E.
EXIT CRITERIA

MISSION ORIENTED ATTD EXIT CRITERIA

The soldier integrated protective ensemble (SIPE) as an aggregate system, should demonstrate a mission profile which enhances the defeat, capture, and/or force withdrawal of the enemy from an assigned objective expeditiously.

SOLDIER ORIENTED ATTD EXIT CRITERIA TO SUPPORT MISSION ACCOMPLISHMENT*

Lethality: The SIPE should enhance the soldier's capability to effectively acquire, engage, and incapacitate enemy soldiers at increased distances, with improved accuracy, and greater efficiency, regardless of the time of day or weather conditions.

Command and Control: The SIPE should facilitate greater command and control of soldiers in order to effectively influence the battlefield. When directed, priority information must be obtained in less time and more effectively.

Survivability: The SIPE should provide greater personal protection from battlefield hazards and enemy weapon systems. It should aid in the detection of the enemy's presence before the soldiers themselves are detected. It should reduce the possibility of soldiers becoming casualties.

Sustainability: The SIPE should provide increased reliability, greater operational time, less maintenance, and facilitate overall ease of support to and for the soldier.

Mobility: The SIPE should provide a lightened soldier load, with greater equipment integration, improved configuration, and increased utility.

Training: The SIPE should facilitate the training of the individual soldier and assist in maintaining combat/system proficiency.

SUBSYSTEM CRITERIA

INTEGRATED HEADGEAR

Inclusive Soldier System Modules: Ballistic, C4I, Electro-Optic, Chemical/Biological and Weapon.

ATTD Minimums.

Show a contribution toward improving engagement performance in all weather, day or night, through battlefield obscurants, to include firing under NBC conditions (relative to baselines established during ATTD*).

Demonstrate utility for Command, Control, Communication, Computer, and Intelligence (C4I) enhancement.

*NOTE: Performance will be measured against existing current baselines and, where applicable, baselines which will be established during the advanced technology transition demonstration (ATTD) operational demonstration.

Goals.

Significantly increased engagement performance in all weather, day or night, through battlefield obscurants, to include firing under NBC conditions (relative to baselines established during ATTD*).

Demonstrate a fully integrated helmet which increases the soldier's C4I capability with a significant head supported weight reduction (measured against ATTD multiple component baseline), soldier navigation, and embedded interactive training capability.

ADVANCED CLOTHING

Inclusive Soldier System Modules: Clothing and individual equipment, ballistic, chemical/biological and load bearing.

ATTD Minimums.

Demonstrate an increase in soldier protection from chemical/biological agents, flechette munitions, and flame weapons. Demonstrate an increase in soldier wear time in a chemical/biological environment.

Provide a better configuration of the soldier's fighting load that enhances comfort for wear over greater periods of time, with improved utility, balance/distribution, as well as a weight reduction over that which is currently attainable.

Goals.

Demonstrate a marked enhancement in soldier protection from flame weapons and all known chemical/biological agents over prolonged periods of time. Soldiers should not become incapacitated as result of flechette penetration of protected areas.

Demonstrate an integrated system, with improved configuration, better utility, and a significant reduction in weight.

MICROCLIMATIC CONDITIONING/POWER

Inclusive Soldier System modules: Chemical/biological and microclimate conditioning/power.

ATTD Minimums.

Sustainability. Demonstrate an enhancement to the soldier's mission accomplishment in a chemical/biological environment without increased support.

Goals.

Demonstrate a range of capabilities to regulate thermal equilibrium.

*NOTE: Performance will be measured against existing current baselines and, where applicable, baselines which will be established during the advanced technology transition demonstration (ATTD).

Appendix F.
System Level Issues and Criteria

F.1 Lethality. The SIPE should enhance the capability of the soldier and squad to effectively acquire, engage, and incapacitate enemy soldiers at increased distances, with improved accuracy, and greater efficiency, regardless of the time of day or weather conditions.

F.1.1 Issue. What are the comparative capabilities of SIPE equipped soldiers and baseline equipped soldier to employ their individual and crew served weapon systems.

F.1.1.1 Scope. The capabilities of SIPE equipped soldiers compared to the capabilities of baseline soldiers equipped with weapons and optics organic to the light infantry squad, will be examined. SIPE equipped soldiers and baseline soldier performance data for training, simulated tactical exercises, and day/night range firing will be examined. Baseline soldiers will be equipped with M16A3 with Thermal Weapons Sight (TWS) if available. Data requirements include:

a. Day sight vision to maximum ranges (greater than or equal to 500 meters); target detection, location and recognition under conditions of obscurants, existing weather, and at varying levels of MOPP, to include range to detect targets (visually, audibly).

b. Night sight vision to maximum ranges (greater than or equal to 400 meters in starlight; and greater than or equal to 600 meters in moonlight); target detection, location and recognition under conditions of darkness, obscurants, existing weather, and at varying levels of MOPP, to include range to detect targets (visually, audibly).

c. Percentage of hit out to weapons' maximum effective ranges (including 300 meters and 500 meters); under conditions of daylight and darkness, obscurants, existing weather, and at varying levels of MOPP.

d. Perceived firing effectiveness.

e. Firing using indirect viewing.

F.1.1.2 Criteria. None.

F.1.1.3 Rationale. This issue is investigative in nature. Assessment and simulation/modeling data will be judged against approved exit criteria during the evaluation process.

F.1.1.4 Source.

C4I Module Evaluation.
Electro-Optics Module Evaluation.
Weapons Module Evaluation.
Operational Assessment Evaluation.
Modeling and Simulation

F.2 Command and Control The SIPE should enhance the capability of the soldier to direct, coordinate and control communication and information dissemination based upon the mission. It should facilitate the units ability to perform the procedures necessary for effective mission performance in a timely and tactically secure manner.

F.2.1 Issue. What are the comparative capabilities of SIPE equipped soldiers and baseline equipped soldiers to execute Command and Control (C2)?

F.2.1.1 Scope. This issue will examine the C2 capabilities of SIPE equipped soldiers compared to those of the baseline soldiers. Data will be collected during all phases of assessment, simulation and modeling. Data requirements include:

a. Effectiveness of intrasquad communications radio transmissions, non-radio transmissions, and unaided voice.

(1) Clarity/intelligibility of communications.

(2) Speed and accuracy of transfer of information.

(3) Time to implement orders/react.

b. Effectiveness of Command and Control of unit when stationary (during defense and short halts); type of terrain (line of sight); and squad dispersion.

c. Effectiveness of Command and Control of unit during movement; type of terrain (line of sight and non-line of sight); and squad dispersion.

d. Effectiveness of information management.

(1) Video capture/battlefield intelligence.

(2) Preformatted message/prompts.

(3) Calls for fire support.

(4) Identify Friend or Foe (IFF).

F.2.1.2 Criteria. None.

F.2.1.3 Rationale. This issue is investigative in nature. Assessment and simulation/modeling data will be judged against approved exit criteria during the evaluation process.

F.2.1.4 Source.

C4I Module Evaluation.
Electro-Optics Module Evaluation
Operational Assessment Evaluation
Modeling and Simulation

F.3 Survivability. The SIPE should provide greater personal protection from battlefield hazards and enemy weapon systems. It should aid in the detection of the enemy's presence before the soldiers themselves are detected. It should reduce the possibility of soldiers becoming casualties.

F.3.1 Issue. What are the comparative capabilities of SIPE equipped soldiers and baseline equipped soldier to survive battlefield hazards and enemy weapon systems.

F.3.1.1 Scope. The capabilities of SIPE equipped soldiers compared to the capabilities of baseline soldiers equipped with protective equipment organic to the light infantry squad, will be examined. SIPE equipped soldiers and baseline soldier performance data for training, simulated tactical exercises, and day/night range firing will be examined. Baseline soldiers will be equipped with the Personnel Armor System Ground Troops (PASGT), the Overgarment 84 (OG84) chemical protective garment, the M40 series protective mask, and the chemical protective hood, gloves and over boots. Data requirements include:

a. Task accomplishment time.

b. Lethal area of ballistic protective clothing.

F.3.1.2 Criteria. None.

F.3.1.3 Rationale. This issue is investigative in nature. Assessment and simulation/modeling data will be judged against approved exit criteria during the evaluation process.

F.3.1.4 Source

Clothing and Individual Equipment Module Evaluation.
Ballistic Module Evaluation.
Chemical/Biological Module Evaluation.
Microclimatic Conditioning/Power Unit Module Evaluation.
Modeling and Simulation

F.4 Sustainability The SIPE should provide an enhanced capability to maintain the soldier/unit in a tactical environment. The soldier should realize enhanced operational time, greater clothing and equipment reliability and less maintenance of the same.

F.4.1 Issue. What are the comparative sustainment requirements of SIPE equipped soldiers versus baseline equipped soldier.

F.4.1.1 Scope. The sustainment requirements of SIPE equipped soldiers compared to the sustainment requirements of baseline soldiers equipped with weapons and optics organic to the light infantry squad will be examined. The amount of water, food, and other supplies as well as rest required by the SIPE equipped soldier versus the baseline equipped soldier will be examined. Data requirements include:

a. Quantity of water consumed.

b. Quantity of food consumed.

c. Quantity of other supplies consumed.

d. Maintenance required.

e. Soldier endurance.

F.4.1.2 Criteria. None.

F.4.1.3 Rationale. This issue is investigative in nature. Assessment and simulation/modeling data will be judged against approved exit criteria during the evaluation process.

F.4.1.4 Source.

Clothing and Individual Equipment Module Evaluation.
Chemical/Biological Module Evaluation.
Microclimatic Conditioning/Power Unit Module Evaluation.

F.5 Mobility. The SIPE should enhance soldier and unit ability to accomplish mission tasks and tactical maneuvers over various terrains and under various environmental conditions. For the individual soldier the SIPE should provide a lightened, balanced load with greater equipment integration and increased utility. SIPE should provide the squad with the capability to tailor the ensemble configuration to the mission of each squad member thereby enhancing the unit performance.

F.5.1 Issue. What is the comparative mobility of SIPE equipped soldiers and baseline equipped soldiers. Data will be collected throughout all assessments/evaluations and modeling and simulations.

F.5.1.1 Scope. This issue will examine those areas in the SIPE program assessments and evaluations related to soldier and squad maneuverability with soldiers displaying SIPE capabilities versus those displaying baseline capabilities. Data requirements include:

a. Distance over time.

b. Indirect viewing during movement/maneuver.

c. Individual and unit movement through obscurants.

d. Effectiveness of movement/maneuver due to Geographical Position System (GPS)/mapping.

e. Traction/agility.

f. Soldier freedom of movement.

g. Time to implement maneuver upon receipt of orders.

F.5.1.2 Criteria. None.

F.5.1.3 Rationale. This issue is investigative in nature. Assessment and simulation/modeling data will be judged against approved exit criteria during the evaluation process.

F.5.1.4 Source.

Clothing and Individual Equipment Module Evaluation.
Ballistic Module Evaluation
Load Bearing Module Evaluation.
Chemical/Biological Module Evaluation.
C4I Module Evaluation.
Operational Assessment Evaluation.
Modeling and Simulation

F.6 Training. The SIPE should provide more efficient and effective training for soldier/unit on the modular system capabilities commensurate with their target audience descriptors. It should reduce the overall costs to the unit utilizing embedded training and training devices whenever possible.

F.6.1 Issue. How well does the embedded training features of SIPE provide for training transfer.

F.6.1.1 Scope. This issue will examine the impact of training methodologies on SIPE equipped soldiers and units to develop critical skills in preparation for combat. The effects of embedded training and training devices will be collected throughout all phases of assessment, simulation and modeling. Particular attention will be given to critical skill development, potential for proficiency sustainment and individual and collective skill integration. Data requirements include:

a. Effectiveness of the transfer of embedded training capabilities to tactical applications; e.g., formats, checklists, graphics, instructions, target lists, mission planning aids, etc.

b. Potential to capture/store/retrieve/transmit performance feedback (training and tactical).

c. An analysis of the potential to reduce conventional training resource requirements with respect to soldier/unit time spent, facilities, hours, dollars, equipment and devices, training technology and logistics.

d. An analysis of current training doctrine, and changes to that doctrine may be needed as a result of the enhanced capabilities of the SIPE soldier/unit.

F.6.1.2 Criteria. None.

F.6.1.3 Rationale. This issue is investigative in nature. Assessment and simulation/modeling data will be judged against approved exit criteria during the evaluation process.

F.6.1.4 Source.

Integrated Headgear Subsystem Evaluation.
C4I Module Evaluation.
Operational Assessment Evaluation.
Modeling and Simulation

Appendix G.
Measures of Performance

H.1 LETHALITY - % of targets detected
- % of targets acquired
- % of targets hit

H.2 COMMAND & CONTROL (C2) - % message completion
- % land navigation course
  % points found
  time to complete course

- STX/FTX measures
  task performance on common tasks
  task performance on land navigation tasks

H.3 SURVIVABILITY Technical in nature, not planned for assessment in operational assessment.

H.4 SUSTAINMENT (Training) -STX/FTX task performance aided by SIPE embedded training
- Individual performance in structured training events
- % favorable/unfavorable soldier questionnaire responses (not comparative)

H.5 MOBILITY - comparative weights
- % favorable/unfavorable soldier questionnaire responses (not comparative)
- STX/FTX task performance on mobility related tasks

Appendix H.
Operational Assessment Baseline Soldier Equipment

The Baseline soldier during the operational assessment will be equipped with:

Battle Dress Uniform (BDU)
Combat Boots
PASGT Helmet
PASGT Vest
Ballistic Laser Eye Protective System (BLEPS)
Load Bearing Equipment (LBE) w/belt
Canteen, 1 qt, w/cover
Battle Dress Overgarment (BDO)
AN-PVS 7
M16A3 or M16A2 Rifle
M40 Protective Mask
M6A2 Hood
CB Gloves/Foot Covers
CB Helmet Cover

APPENDIX C.

SUMMARY OF PLAYERS

SUMMARY OF PLAYERS

CECOM Night Vision and Electro Optic Directorate (NVEOD)

Institute for Defense Analyses (IDA)

Surgeon General (ARIEM)

U.S. Army Chemical RD&E Center

U.S. Army Communications and Electronics Command (CECOM)

U.S. Army Human Engineering Laboratory (HEL)

U.S. Army Infantry School (USAIS)

U.S. Army LABCOM Electronic Technology & Devices Laboratory (EDTL)

U.S. Army LABCOM Harry Diamond Laboratories (HDL)

U.S. Army Natick RD&E Center (Natick)

U.S. Army Research Institute (ARI)

U.S. Army Test & Experimentation Command (TEXCOM)

U.S. Army Training & Doctrine Command (TRADOC/TSM Soldier)

4th Ranger Training Battalion (RTB)