The United States Army Future Force Warrior – An Integrated Human Centric System

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1.0 UNITED STATES ARMY APPLICATION OF HUMAN SYSTEMS INTEGRATION

The primary objective of Defense Acquisition in the United States is to acquire quality products that satisfy user needs with measurable improvements to mission capability and operational support, in a timely manner, and at a fair and reasonable price.[1] In the interest of achieving this goal, Materiel Developers are directed to apply the principles of Human Systems Integration (HSI) to optimize total system performance (hardware, software and human), operational effectiveness (the overall degree of mission accomplishment of a system), and operational suitability (the degree to which a system can be placed satisfactorily in field use), survivability, safety and affordability.[2] In short, Materiel Developers must ensure that systems are built to accommodate the characteristics of the user population that will operate, maintain, and support the system. This is achieved by ensuring the "human" is fully and continuously considered as part of the total system. Human performance is a key factor in "total system performance" and enhancements to human performance correlate directly to enhanced total system performance and reduce life cycle costs.

The Department of the Army developed and established a program entitled MANPRINT, which stands for Manpower and Personnel Integration, that addressed and implemented the DoD Directive regarding Human Systems Integration.[3] In fact, the importance and success achieved by the Army's early MANPRINT program led the Office of the Secretary of Defense to adopt the concept for the entire Department of Defense.[4]

The terms Human Systems Integration (HSI) and MANPRINT are synonymous. The difference between them is simply that the term "HSI" is a term used by all the Services, whereas MANPRINT is typically only used by the US Army. MANPRINT is a comprehensive management and technical program designed to improve total system (Soldier and equipment) performance by ensuring that the human is fully and continuously considered as part of the total system in the development and/or acquisition of systems. Similar to HSI, MANPRINT is an umbrella term that refers to seven disciplines that are critical to optimizing the man-machine, total-system approach. They are Manpower, Personnel, Training, Human Factors Engineering, System Safety, Health Hazards, and Soldier Survivability.[5]

[1] DoD Directive Number 5000.1, dated May 12, 2003, Subject: The Defense Acquisition System.
[2] DoD Directive Number 5000.1, dated May 12, 2003, Subject: The Defense Acquisition System, Enclosure 1, para E1.29.
[3] Army Regulation, AR 602-2: MANPRINT in the System Acquisition Process.
[4] www.manprint.army.mil – MANPRINT History.
[5] Congressional Record, Speech given by Honorable lke Skelton to the House, *dated October 1, 1997*.

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The first three domains, Manpower, Personnel and Training are closely related and refer to the numbers and types of personnel required to operate, maintain & sustain systems and the instructions, education or on-the-job training required to provide those personnel with their essential job skills & knowledge. When considering these domains, we ensure that the manpower required to support a new system are available and that they possess the appropriate cognitive and physical characteristics, as well as necessary training to effectively operate, deploy/employ, maintain and support that system.

The domain of Human Factors Engineering (HFE) pertains to the integration of human characteristics into system definition, design, development & evaluation to optimize human-system performance under operational conditions. The goal of HFE is to maximize **the ability of an individual** or crew to **operate** and maintain a system at required levels by enhancing performance and eliminating **design-induced difficulty and error**. Successful implementation of HFE occurs when it is conducted during all phases of system development, to include requirements specification, design and testing and evaluation. It is most effective if included from the beginning of the development and acquisition program.

The System Safety and Health Hazards domains relate to the inherent ability of the system to be used, operated, and maintained without accidental injury to personnel and the inherent conditions in operation or use of a system (e.g., toxicity, heat stress) that can cause death, injury, illness, disability, or reduce job performance. Safety and Health considerations are vital to protect our Soldiers from injuries and illnesses, and to prevent mission degradation or failure.

Finally, the Soldier Survivability domain refers to the characteristics that reduce fratricide, detectability and probability of being attacked, as well as minimizing system damage, Soldier injury and cognitive and physical fatigue. This last domain was added to focus attention on those aspects of the total system that can maximize situational awareness and in turn minimize the loss of friendly troops' lives.

These seven MANPRINT domains, while representing separate elements, are all interrelated and impact one another. For example, increased attention to Human Factors Engineering characteristics should lead to more effective Soldier performance with less error, thus decreasing any negative safety implications associated with a system. The return on this investment is reflected in reduced occurrences of accidents. This not only positively impacts our Soldiers and mission performance, but also ultimately saves money and yields more output per Soldier. The central idea is to integrate considerations of these domains continuously into the acquisition process so that ultimately we have optimized our combat readiness.

Regardless of the type of acquisition program, successful implementation of MANPRINT occurs at the conception of the program's acquisition process. MANPRINT is typically established within the framework of the program's Systems Engineering Team, with a MANPRINT Specialist assigned as a dedicated member of this team. This allows for MANPRINT to be an active part of every aspect of the acquisition process – from the establishment of operational requirements, during the analysis of alternatives, through the development of prototypes or models, to the test and evaluation and fielding process. MANPRINT participation enables a hands-on approach to the design and development, which includes participating in the decision-making processes and the assessment of risks and trade-offs encountered throughout the program's development.

2.0 THE SOLDIER AS A SYSTEM

Even with the advent of MANPRINT in the Army, the development of items and systems designed to equip the Soldier were done one at a time. By that I mean that items would be developed to enhance Soldier capabilities and then literally "hung" on the individual much in the same manner that ornaments are hung on a Christmas tree. Not enough attention was paid to the three levels of integration (described below) during early development of the items, and systems would often have to go back to the drawing board to be "retrofitted" for compatibility. In addition to being a costly process over the long run, an item or system might actually lose some of their capability when compared to their performance as stand-alone items.

In many ways the acquisition process for obtaining new or improved systems enabled this non-integrative approach, especially for the items a Soldier wears, carries or consumes. While the acquisition process is complex and continually evolving, a primary constant in the process, regardless of its configuration at any time, is that every item must be backed by a requirement from the user. However, requirements have most often been recognized one at a time rather than within the context of the whole system. This is particularly true for items the Soldier wears, carries or consumes.

At the very heart of the Soldier-centric "system-of-systems" approach resides the concept of integration, which can be understood in three critical ways. First, integration can be viewed as the interaction and compatibility of Soldier-borne systems with the human. The systems must not, by virtue of their construction or function, directly negatively affect the human, anatomically, physiologically, or mentally. A second, more intricate level of Soldier-centric integration is the inter-compatibility of all the systems actually borne on and used by the Soldier. For example, individual protection systems such as ballistic protective upper body garments must be compatible with load-bearing systems; the ballistic vest cannot tilt the helmet and head forward when in the prone position, and so forth; electronics must be fully integrated into protective systems, including uniforms, so as not to degrade the performance of either system through physical snagging, electromagnetic interference, or other inhibitors, etc. Finally, from a broad perspective this Soldier-oriented "system-of-systems" must be compatible and interface with large, complex systems with which the Soldier interacts on the battlefield such as helicopters, tanks, and other vehicles, and most recently, with the "Network." The Soldier system and all it comprises must work synergistically with those large systems. For example, the Future Combat System will transport Soldiers, provide defense for Soldiers (including non line of sight, remote fires), and essentially serve as a mother-ship for warfighters. The efficacy of the FCS system therefore ought to be measured by how well it can accomplish its missions both with and for Soldiers, resulting in swift combat outcomes with minimal casualties. What is clear is that the lack of integration can degrade human performance that, in turn, ultimately results in endangerment of our nation's warfighters and mission degradation.

Driven by the Army's Soldier Materiel and Combat Development community, particularly the Natick Soldier Center and the Program Executive Office Soldier, the Soldier as a System (SaaS) concept was formally approved by the Training and Doctrine Command in November 2001. As taken from a recent draft version of TRADOC Pamphlet 525-x (dated 26 July 2005; p. 11), the Soldier as a System concept is defined as follows:

> *The SaaS Concept includes all Soldiers and is focused on individual tasks derived from Army Tactical Tasks that all Soldiers must be capable of performing in support of current and future force operations. The Soldier System includes the Soldier and those items and equipment the Soldier wears, carries, or consumes. It includes all items in the Soldier's load and those items of equipment to accomplish individual tasks and missions (for example, crew-served weapons, inter-unit radios) that the Soldier must carry. The Soldier System includes physiological, as well as applied capabilities and*

considerations for the operational environment (both natural and man induced) that range from home station to the battlefield. This concept includes the full range of Doctrine, Organization, Training, Materiel, Logistics, Personnel, and Facilities enablers that must be addressed in a holistic manner to ensure a fully capable Soldier System...

As a result, a family of Soldier-related Capability Development Documents (CDD), or requirements documents, for the SaaS concept was produced and are in the process of review and approval. They span the Doctrine, Organization, Training, Materiel, Logistics, Personnel, and Facilities (DOTMLPF) spectrum. These requirements documents are aimed at addressing all Soldier needs across all capability areas (e.g., survivability, sustainability, mobility, lethality, etc.) in a comprehensive, integrated manner. They are designed to streamline the acquisition process by encompassing the vast majority of individual Soldier Systems within a suite of four comprehensive, SaaS Capability Development Documents and consist of the Core Soldier System; the Ground Soldier System; the Mounted Soldier System; and the Air Soldier System. The Core Soldier will have the common threads that each of the other three will build upon for their specific, unique requirements and capabilities.

Implementation of the Soldier as a System concept will greatly enhance the development and acquisition of Soldier Systems such that the warfighter receives not only the best equipment possible as quickly as possible, but also the right equipment for all possible missions. The three levels of integration thus become ingrained in the developmental fabric of all Soldier Systems. And taken to the next level, this integrated System of Systems approach allows for a reexamination of the way we fight. No longer will the Soldier, especially the Core and Ground, be a system looking at a System of Systems battlefield from the outside, he or she will actually become part of a grander System of Systems, which takes the Combined Arms and Joint fight to the next level.

3.0 FUTURE FORCE WARRIOR – AN INTEGRATED HUMAN CENTRIC SYSTEM

The Soldier System concept was introduced in 1989 when a new program to develop the first comprehensive, integrated Soldier System was initiated by the Natick Soldier Center. Called the Soldier Integrated Protective Ensemble, this was the precursor of today's Land Warrior and tomorrow's Future Force Warrior. The Army Science Board, in a study supported by the Natick Soldier Center, reinforced the wisdom of this approach and concluded in 1991 that the Soldier should be considered as a functioning system in the same manner as tanks or helicopters.

The Land Warrior Program evolved from desirable combat capabilities demonstrated during the Soldier Integrated Protective Ensemble Advanced Technology Demonstration. It has undergone many modifications during its System Development and Demonstration and a recent comparison demonstration with current force equipment, clearly demonstrated Land Warrior was superior in providing small combat team awareness and effectiveness.

The Land Warrior program is now structured to provide a Battle Command and Situational Awareness capability to serve the operational needs of Soldiers engaged in the dismounted fight. The four step incremental development strategy parallels that of the Army's Future Combat System. The four increments are:

First, the Dismounted Battle Command System (DBCS). The DBCS increment will field the hand-held Commander's Digital Assistant (CDA) and Enhanced Position Location and Radio System or MicroLight

radio to Brigade Combat Teams to assist Soldiers in navigation and threat notifications, mission planning functions and blue force tracking capability.

The second increment is the Land Warrior Ensemble itself. This increment will provide Soldiers in Stryker Brigade Combat Teams with expanded situational awareness through Tactical Internet connectivity, vehicle-to-dismounted Soldier communications, and Soldier-to-Soldier communications while mounted and dismounted. The Land Warrior Increment includes current weapons, a laser rangefinder, thermal weapon sight visual displays, integrated load carrying equipment with ballistic protection, protective clothing, helmet with speaker, microphone and helmet-mounted display, computer, navigation, radio, and controls with a consistent and intuitive interface for use under battlefield conditions. These components are linked together into a system to support the mission of the dismounted combat Soldier.

While the Land Warrior ensemble combines these with newly developed software and hardware components into an integrated system, it lacks the holistic system-of-systems design that would provide the more streamlined integrated modular system most desired by the user.

The third increment will be the Ground Soldier Threshold System. This increment addresses Future Force operational needs for the Soldier within the Unit of Action and is expected to be fielded in 2012. This fully-integrated modular system will meet the threshold requirements of the Ground Soldier System CDD. The Future Force Warrior Advanced Technology Demonstration will provide the technological basis and initial design for this increment which will provide ALL dismounted Soldiers with improved capabilities in lethality and survivability and which will be enhanced for Unit of Action Soldiers who are interoperable with the various vehicle platforms being developed within the FCS program and integrated within the Future Force Network.

The Ground Soldier Objective System is the fourth increment and is expected to be fielded in 2016. This increment builds on the Ground Soldier Threshold increment and fields a fully integrated version of the ensemble with improvements focused on Ground Soldier System CDD Objective requirements, and fully maximizes Ground Soldier utility of the FCS Network and Networked platforms. The Ground Soldier Objective capability will incorporate mature technologies from future science and technology efforts, in particular from follow-on Future Force Warrior work.

In the realm of Science and Technology, the Future Force Warrior Program represents a “system-of-systems” program where the Soldier/human is the centerpiece. The Future Force Warrior (FFW) Advanced Technology Demonstration (ATD) is the US Army’s flagship Science & Technology (S&T) program that, as noted above, will transition to the Ground Soldier System acquisition program, the third Land Warrior increment that will be fielded with the Future Combat System (FCS).

Today’s dismounted Soldiers are physically overloaded, have insufficient situation awareness (SA), and are inadequately networked to other platforms to provide combat overmatch as part of the future force. The Future Force Warrior Advanced Technology Demonstration will provide a prototype system that significantly attenuates or reduces, if not eliminates, these problems. Further, subsystems and components, backwards compatible with Land Warrior and current Soldier ensembles, will be transitioned to fielded systems to ensure continuous enhancements to the current force.

The fundamental tenets of the Future Force Warrior program are to accomplish the following using a human-centric design paradigm:

- Provide Collaborative Capabilities Distributed Across the Small Combat Unit.
- Reduce the Weight of the individual warfighter and the small combat unit.
- Amplify & Extend the Ability to See & Hear First.
- Rapidly Know, Understand, Decide & Adjust On the Move.
- Multiply the Ability to be Overwhelmingly Lethal.
- Extend the Ability to Survive and Endure Longer Missions.
- Optimize the Concept of Operations for the Small Combat Unit – *Change the way we Fight.*

The FFW program, as the S&T precursor to the Land Warrior Ground Soldier System program, is designed to provide the framework for Soldier System development activities in the mid and long terms. The FFW ATD will execute a Capstone Demonstration in 4Q07 during which it will demonstrate its FFW System of Systems (SoS), determine if FFW meets its exit criteria or critical performance metrics, and validate the technology and system maturity. [Charts 1 and 2 list the technologies being developed that will result in enhanced capabilities.] The FFW SoS includes a number of capabilities designed to provide revolutionary improvements in Soldier and small combat unit warfighting capabilities. FFW's Netted Fires capability provides for cooperative engagement within the Small Combat Unit (SCU) and manages, integrates and synchronizes combat power with Future Combat System (FCS) and joint fires. The Networked Communications capability provides SCU information dominance with superior Situation Awareness (SA), synchronized platoon combat power, faster decision cycles and operational tempo. These two capabilities in particular allow for the SCU to harness the power of the larger force via the Future Force network. An integrated, modular, tailorable combat-specific ensemble improves Soldier and SCU mobility and fightability, enhances environmental and threat protection and reduces the weight of the Soldier's fighting load. FFW will interface with the FCS robotic platforms, provide increased lethality and area of influence via enhanced SA, networking, Intelligence, Surveillance and Reconnaissance and tactical maneuver for the SCU, and the ability to off-load Soldier equipment (e.g. water, ammunition) onto a "MULE." Lightweight hybrid power systems and power management technologies provide for longer mission duration without resupply. Personal Status Monitoring provides enhanced triage and casualty evacuation and supports SCU leader assessment of unit readiness. Training and Leader Development creates mission ready Soldiers via Embedded Training and collaborative planning.As noted, the FFW ATD program has as one of its basic tenets, a human-performance-centric design. This has been addressed through a variety of means. One key method was a robust implementation of a MANPRINT/HSI program.

The Future Force Warrior Program included MANPRINT in the earliest phases of the conceptualization of the program with a dedicated MANPRINT Team established to ensure integration of MANPRINT into the systems development contract. Established as part of its System Engineering efforts, this team is responsible for assisting in all design and development of FFW components, subsystems and systems. MANPRINT is horizontally linked to the system designers to insure the success of the program. The organizational placement of MANPRINT in System Engineering allows for MANPRINT to influence critical System Engineering efforts such as requirements derivation and Analysis and Experimentation.

The application of Human Systems Integration within the FFW program goes beyond the traditional static review of program and technical documentation for HSI-related issues and the 'arm's length' approach to identification of human factors-related issues practiced in the early years of MANPRINT. The FFW

program's HSI effort combines standard HSI practices with technology investigation and application. The goals of FFW's MANPRINT Team are to:

- Execute: a MANPRINT program incorporating task decomposition and analysis; a comprehensive Human Factors Engineering program; program-wide system safety and health hazard analysis, documentation and support; MANPRINT domain-related analysis and assessments; definition and development of guidelines for Soldier machine interfaces; and provision of system-wide guidance on Soldier-System of Systems Management and Control.
- Influence design and assess implementation of the FFW technical solution.
- Track and manage/mitigate MANPRINT-related risks.
- Assist management in ensuring MANPRINT technical and program metrics are met.

Future Force Warrior's Human Systems Integration efforts also serve as the doorway for human performance-based technologies to be incorporated into the FFW System of Systems. FFW takes a holistic approach to development in that it provides capabilities to better EVERY aspect of the Soldier from the Soldier as a physical/cognitive being (e.g. personnel status monitoring, aided cognition) to the Soldier as a member of a highly functioning military unit (e.g. collaborative situation awareness).

There are new tools and techniques for HSI domain analysis which are being utilized in the FFW ATD. For example, in the general area of human performance modeling we can (1) model workload with a high degree of specificity using the IMPRINT model, (2) evaluate cognitive function in a field environment using the Cognitive Readiness Test Battery, (3) model space claim and volumetrics using the JACK model, and (4) model the demand for special skills or qualifications based on an understanding of operational requirements using the JASS (Job Assess Software System). These are tools the FFW HSI effort has used or is using in our application of HSI to system of systems development.

FFW's method of application of Human Systems Integration not only enables effective use of these tools and techniques to the HSI domains but also allows for the leveraging of HSI-related technologies into system design via the system engineering process. This added dimension allows for a truly Soldier centric perspective by incorporating technologies that enable the physical/cognitive element of the Soldier-System, the Soldier, to perform better. In addition, the FFW program has a number of technologies that actively address HSI-related areas of individual and unit operations.

For example, the Soldier Protective Individual Equipment System (SPIES) is made up of multiple subsystems supplying various elements of the Soldier's individual combat and survival needs on the battlefield. The SPIES is a "combat only" ensemble and serves as the integration platform for all other FFW components, subsystems and systems. The SPIES is made up of a Multifunctional Combat Uniform, Integrated Load Carriage/Body Armor, the Personal Area Network or PAN, and the personal status monitoring system (WPSM). Let me focus on the Integrated Load Carriage/Body Armor.

The Integrated Load Carriage/Body Armor subsystem, or "chassis," integrates load carriage and ballistic protection around the torso and extremities in a single integrated system. The subsystem is unique in that it provides a stand-off of the armor chassis to the body allowing for enhanced passive thermal management, and a single unit design that promotes optimal carriage of the fighting and approach march loads. Based on a human factors driven design, the Load Carriage/Body Armor subsystem has the following characteristics:

- Improved mobility.
- Increased ballistic coverage.

- Lightweight ballistic materials.
- Optional up-armor components.

Multiple fightability evaluations have been conducted that focus on the SPIES. These evaluations generally consisted of active duty Soldiers conducting individual Soldier maneuvers based on a structured experimental design. Across evaluations different issues came up consistently that required design changes. For example, Soldiers in three or more studies raised the issue of low-back discomfort with the SPIES Chassis. FFW conducted a series of assessments to narrow down the cause of the discomfort and redesigned the Chassis to eliminate the problem.

The Soldier Protective Individual Equipment System Chassis is a clear case of 'out of the box' thinking with regards to novel ways of resolving key human factors challenges as designs evolve. Its design is representative of a key Human Systems Integration tenant - human factors driving system design and testing. The inherent structure as well as the offset of the armor from the body is central to the design and provides major benefits to the Soldier with respect to Human Factors through passive thermal management, load carriage and overall comfort. The design also recognizes that when struck, the ballistic protection plate deforms and can transmit the force to the body if not offset. Further, the integrated nature of the chassis and its complex of pads dissipate the energy of a bullet or fragment across a much broader area reducing the possibility of a secondary injury. Taking on the task of characterizing the ballistic properties of the materials started with ballistic testing of the hard armor offset concept. This testing addressed the characterization of ballistic plate integrity and performance in a stand alone (i.e., without back face support by either a soft armor system or by the body directly) and stand-off (i.e., an air gap between the plate and the body) configuration. The integrity of the plates was not compromised by the unsupported stand-off. These results validated the basic design underpinnings contained in the Chassis and demonstrates a structural armor system then does not degrade ballistic performance but likely enhances it by reducing blunt trauma; that reduces weight by eliminating the need for a soft armor material system behind the hard ballistic plate; that provides a very stable load carriage platform that enhances comfort and stability; and that provides air flow next to the body, enhanced by a combat shirt that wicks away moisture, critical to thermal management and reduction of heat stress. The chassis design with its 11 pads also addresses the current body armor's difficulty in proper fit for women below the bust-line.

Other examples of Human System Integration applications in the Future Force Warrior System are the Warrior Physiological Status Monitoring System, Augmented Cognition, System Voice Control, Heat Stress Management, and Embedded Training.

3.1 Warfighter Physiological Status Monitoring

The Warfighter Physiological Status Monitoring (WPSM) system provides remote monitoring of Soldier health. This is an example of a technology that focuses specifically on the human and his or her status on the battlefield. Designing the WPSM integral with the SPIES provides the opportunity to take advantage of the stand-off area afforded by the load carriage chassis in addition to leveraging the body-worn FFW computer processor and radio.

Through its sensors and status assessment algorithms, the WPSM system provides the capability for remote Soldier monitoring and enhanced casualty assessment and care. It allows for consolidation of individual Soldier status into unit status for assessment of unit mission readiness & potential combat effectiveness. It also prevents / reduces the risk of non-battle injury, rapidly identifies battlefield casualties, and automates the reporting process for medical support requests, medevac, logistic requests and medical history availability.

The WPSM system increases efficiency in directing medical aid / resources to the injured through sensors and physiological algorithms that assist with preventing injury and in remote triage assessment enabling expedited triage decisions by leaders and medics in hostile environments. The system consists of:

- Life Signs Detection System with sensors that monitor heart and respiration activity, body orientation, ballistic impact, skin and core temperature.
- Sleep and Performance Monitor that assesses sleep state and quantifies the impact of any deficiencies.
- The Theater Medical Information Program approved Electronic Information Carrier (formally called the Personal Information Carrier) which records medical history, encounters and treatment data.
- Medical Information /Communication Hub that fuses component sensor data to determine health readiness, cognitive readiness and dehydration/thermal injury risk.

The monitoring subsystem interfaces with FFW's software, training and hardware platform development efforts, including the communication and SA subsystems. Integrating this human-based system into these areas is a major task for FFW. In addition, the developers of this monitoring subsystem are developing a relationship with an Augmented Cognition program underway at the Defense Advanced Research Projects Agency. The WPSM monitoring subsystem will ultimately serve as the physical platform by which the FFW program can take advantage of the benefits of the Augmented Cognition capability described below without added bandwidth and load.

3.2 Augmented Cognition

Myriad information both to and from the Soldier due to FFW's proposed netted communications capability with the Future Force Network can lead to the potential for cognitive overload on the Soldier. FFW's Information Management capability seeks to prioritize messages at critical times thereby improving the likelihood of timely receipt of mission-critical information. In addition, Augmented Cognition technologies provide the potential to further improve overall information management by better managing information flow from the Warfighter's cognitive perspective. Overall, the marriage of these two capabilities has the potential benefit of providing the warfighter a system that makes smart decisions about what information gets presented and when.

Specifically, the Augmented Cognition program looks to develop the means to measure an operator's cognitive state and manipulate it to extend, by an order of magnitude or more, the information management capacity of the computer aided human.

The Augmented Cognition program's initial offering will be the use of physiological sensors resident in the Personal Status Monitoring system to provide the status of the Soldier's cognitive state. This cognitive state information will be made available to leaders to more effectively assess individual and unit readiness.

3.3 System Voice Control

Reduced task time, Soldier survivability, increased Optempo and maneuverability of the Soldier and unit around the battlefield are capabilities that require faster, simpler Soldier Machine interaction and hands-free / eyes-free control of system functions (to include weapons). To achieve these capabilities, the FFW program is implementing a System Voice Control capability. SVC allows for an operator to control various aspects of the system using interactive speech recognition algorithms. System Voice Control technology is not new to the marketplace; however, implementation of this technology in the harsh noise environment of the

dismounted infantryman presents specific technical challenges. Most Speech Recognition capabilities are employed in office-type environments with mostly sedentary operators. In extreme cases, Speech Recognition is used in continuous noise environments again with mostly sedentary operators (e.g. mounted crewmen). The FFW program targets the dismounted infantry Soldier. The environment in which the dismounted infantry Soldier operates contains both impulse and continuous noise sources at significantly high decibel levels. Further, the stress of battle also affects the pitch, pace and clarity of speech. The FFW demonstration is targeting impulse and continuous noises at 90-110 dB-A weighted. The individual FFW will be carrying a wearable computer subsystem controlled by the System Voice Control. Exposure of this subsystem to other environmental stressors including individual Soldier movements across the battlefield, present challenges that the FFW ATD is working hard to overcome to enhance the ability of the Soldier to effectively and easily interact with his/her combat system.

3.4 Heat Stress Management

The threats of Weapons of Mass Destruction requiring encapsulation as well as operations in hot climates have re-emphasized heat stress as a major threat on the battlefield. This, in combination with the physiological stresses Soldiers are under because of physical and cognitive burdens coupled with increasing equipment loads, causes the body's natural thermal management system to be in a continuous state of overload. This presents significant challenges to the materiel developer - to design a system that assists the body's ability to sustain thermal equilibrium without the technical solution adding to the problem (weight, power, etc.). From a thermal heat stress management perspective there are two main types of cooling: passive and active. To provide thermal heat stress management with minimal addition to the Soldier carried load, the FFW program is using a combination of these two. Specifically, the FFW Body Armor/Load Carriage Subsystem is a single integrated system which has an Armor Chassis that provides a standoff of the armor from the torso. This standoff, in addition to the moisture wicking properties of the uniform shirt, allows for air to flow, longitudinally and circumferentially, between the armor and the body and promote evaporative cooling. The uniform shirt is semi-permeable and wicks sweat from the body. The air flowing across the body removes the heat and also keeps the shirt from becoming saturated with sweat allowing for enhanced comfort and a general sense of wellbeing. Evaluation of this subsystem using standard measurement techniques in the laboratory and experimentation in the field with active duty Soldiers bear out these results.

Active thermal management is a tougher problem for a dismounted Soldier due to weight and power constraints. One example of an innovative approach to active cooling is the Army Institute of Environmental Medicine's work on the effects of Skin Temperature Feedback which can be applied to an active feedback system that uses the skin's temperature to indicate when a cooling system should turn itself on and off to keep the body in a state of thermal equilibrium. It is known that when the skin reaches a certain temperature, the blood vessels constrict and the ability of the body to "shed" heat is dramatically reduced. Utilizing skin temperature feedback we can design a cooling system that is not in a constant state of cooling or 'overcooling' which is what we have now in many current active cooling concepts. Instead, by cooling the body in zones, moving from zone to zone based on skin temperature, the amount of power needed to cool the Soldier would be significantly reduced due to the intermittent nature of the cooling. In research done to date, there appears to be no reduction in the physiological or perceptual benefits of Skin Temperature Feedback as compared with constant cooling.

3.5 Embedded Training

FFW, as a system of systems that provides the future Soldier with overmatch capability, will require well trained Soldiers to be proficient in its operation to achieve full system performance levels. Training, and in particular embedded training, will play a key role in reaching this proficiency.

Embedded computer-based training whereby the operational system functions in both training and assessment modes is being pursued. Soldiers will practice on combat tasks using the system, and receive feedback on their performance automatically and in real time. In addition, a learning management system incorporated with the embedded training module will allow trainers to maintain and be aware of each Soldier's status.

Some of the embedded training capabilities being considered for FFW include: embedded tactical engagement simulation that can interface with the Army's Common Training Instrumentation Architecture; embedded skill exercises with performance feedback for sustaining and practicing critical FFW skills and tasks; constructive simulation to train/sustain leader planning tasks; information and performance aids made up of memory joggers/check lists and after action report aides from field exercises. In addition, a reach-back capability to the Army's training repositories for doctrinal materials and existing courseware is planned along with the possibility of using specialized courseware that trains critical FFW skills and interfaces to the Army's future virtual training systems for dismounted Soldiers.

4.0 IN CONCLUSION

Human System Integration efforts are essential to keep Soldier and small combat unit concerns central to successful system engineering and design. Human Systems Integration Practitioners must work hand in hand with the User and materiel development communities to accurately represent Soldiers in the development of system architectures, requirements derivation, test and evaluation, as well as design. This is most emphatically the case for the Soldier System Programs. HSI helps to bridge the gap between the Soldier and the engineer and fulfills a critical need for Soldier System programs.

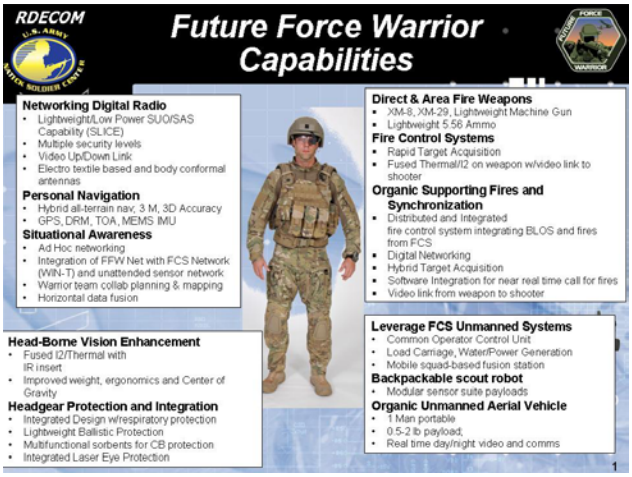

Chart 1

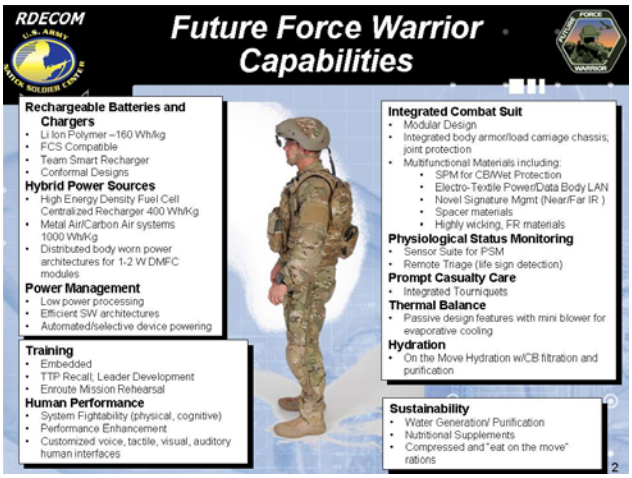
RDECOM
Future Force Warrior
Capabilities
Rechargeable Batteries and Chargers
• Li Ion Polymer ~160 Wh/kg
• FCS Compatible
• Team Smart Recharger
• Conformal Designs
Hybrid Power Sources
• High Energy Density Fuel Cell Centralized Recharger 400 Wh/Kg
• Metal Air/Carbon Air systems 1000 Wh/Kg
• Distributed body worn power architectures for 1-2 W DMFC modules
Power Management
• Low power processing
• Efficient SW architectures
• Automated/selective device powering
Training
• Embedded
• TTP Recall; Leader Development
• Enroute Mission Rehearsal
Human Performance
• System Fightability (physical, cognitive)
• Performance Enhancement
• Customized voice, tactile, visual, auditory human interfaces
Integrated Combat Suit
• Modular Design
• Integrated body armor/load carriage chassis; joint protection
• Multifunctional Materials including:
• SPM for CB/Wet Protection
• Electro-Textile Power/Data Body LAN
• Novel Signature Mgmt (Near/Far IR)
• Spacer materials
• Highly wicking, FR materials
Physiological Status Monitoring
• Sensor Suite for PSM
• Remote Triage (life sign detection)
Prompt Casualty Care
• Integrated Tourniquets
Thermal Balance
• Passive design features with mini blower for evaporative cooling
Hydration
• On the Move Hydration w/CB filtration and purification
Sustainability
• Water Generation/ Purification
• Nutritional Supplements
• Compressed and "eat on the move" rations
2

Chart 2