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20-Year Status Report on the Human Systems Integration (HSI)/Manpower and Personnel Integration (MANPRINT) Soldier Survivability Domain

by Richard N Zigler

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20-Year Status Report on the Human Systems Integration (HSI)/Manpower and Personnel Integration (MANPRINT) Soldier Survivability Domain

by Richard N Zigler

Survivability/Lethality Analysis Directorate, ARL

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Preface

This document is provided as a special report on a short history and the 20-year status of the US Army Human Systems Integration (HSI)/Manpower and Personnel Integration (MANPRINT) Soldier Survivability (SSv) domain after being established by Army Regulation 602-2 on its effective date of 7 October 1994. This report was first initiated as the product of a request by John Lockett of the US Army Research Laboratory's Human Research and Engineering Directorate (ARL/HRED), organizer of the Soldier Performance and Human Systems Integration Technical Advisory Board (TAB), part of the National Research Council (NRC). Mr. Lockett requested a read-ahead for the NRC's TAB panelists that would address the following emphases (see Appendix A):

- Describe the mission and goals of MANPRINT SSv.
- Tell the “story” of MANPRINT SSv.
- Emphasize the “snapshot of the world”: What does the field look like? Give a sense of where we fit in.
- List the programs currently being assessed by MANPRINT SSv.
- List the funding source for each MANPRINT SSv assessment effort.
- List some very significant (unrestricted and unclassified) “crown jewel” technical achievements/findings by MANPRINT SSv.
- Are the SSv assessments performed at an adequate technical level?
- Who does MANPRINT SSv bring in for expertise?
- Are MANPRINT SSv evaluators involved in building an ARL-wide cross-directorate community?
- Does MANPRINT SSv receive public recognition (e.g., in the press and elsewhere)?
- Are MANPRINT SSv evaluators participating on review panels?
- Is there adequate educational outreach on MANPRINT SSv (e.g., serving on graduate committees, teaching/lecturing, invited talks, mentoring students)?
- Are there papers on MANPRINT SSv in conference proceedings?
- Are there awards (external and internal) being given to MANPRINT SSv evaluators?

- What is improving?
- Does MANPRINT SSv represent an area where application of ARL strengths is appropriate?
- What are the available opportunities and the challenges confronting MANPRINT SSv?
- Provide biographical sketches of some key technical leaders for MANPRINT SSv assessments.
- Are the qualifications of the MANPRINT SSv evaluators compatible with the assessment challenge?
- Provide sufficient background information to assist the TAB panel in evaluating their “criteria” of the SSv program.

The original document has been modified with additional details for further clarification of some points.

Many ARL MANPRINT SSv evaluators and system leaders contributed to the information compilation presented here.

1. Introduction: Describe the Mission and Goals of Manpower and Personnel Integration (MANPRINT) Soldier Survivability (SSv)

US Army Regulation (AR) 602-2 established Manpower and Personnel Integration (MANPRINT) in the System Acquisition Process (dated 31 January 2014), Chapter 2 Responsibilities, Section II, Para. 2-15, issued by Commanding General (CG), US Army Materiel Command (AMC).¹ The following is an excerpt of AR 602-2. For more information see Appendix B.

The Commanding General (CG, AMC) will

c.(7): Through the U.S. Army Research Laboratory Human Research and Engineering Directorate – Provide manpower, personnel capabilities, training, and **Soldier survivability** expertise to force modernization and/or branch proponents and IPTs on **nonmajor systems**.

d. Through the Director, U.S. Army Research Laboratory-Survivability/Lethality Analysis Directorate (ARL-SLAD)–

(1) Provide technical ((survivability/lethality/vulnerability) issues related but not limited to conventional ballistics, nuclear, biological, and chemical (NBC), NBC-contamination survivability, electronic warfare, electronic warfare vulnerability of tactical communications systems, information operations/information warfare, atmospheric/obscurants, directed energy weapons, jamming, electronic countermeasures, and personnel vulnerability) advice and assistance to ICTs (integrated concept team) and PM IPTs on Soldier Survivability (SSv) of combat systems (see AR 70-75, Survivability of Army Personnel and Materiel paragraph 2-18d(1)).

(2) Conduct Soldier survivability assessments on ACAT (acquisition category) I and II combat acquisition systems, as appropriate and required. Provide a copy to US Army Research Laboratory Human Research and Engineering Directorate as input to the draft MANPRINT assessment.

For a simplified concept of the how the work is distributed, see Figs. 1 and 2.

Acquisition Category SSv Lead Organizations

ACAT ID = SLAD + HRED
ACAT IC = SLAD + HRED
ACAT II = SLAD + HRED
ACAT III = HRED

Fig. 1 US Army Research Laboratory (ARL) Directorate Assignments for MANPRINT SSv²

● ARL-SLAD:

- Reduce Fratricide
- Reduce Detectability of the Soldier
- Reduce Probability of Being Detected
- Minimize Damage
- Minimize Injury

● ARL-HRED:

- Reduce Physical & Mental Fatigue

Fig. 2 Assignment of MANPRINT SSv² components assessment by ARL directorate expertise

2. Background of Human Systems Integration (HSI)/MANPRINT SSv

During a late-1992 meeting, Army Chief of Staff General Gordon Sullivan asked which Army organization could do something during the acquisition process about reducing fratricide. His motivation for the request was the fact that 24% of battle deaths and casualties had been attributed to fratricide during Operation Desert Storm. As no other organization at the meeting volunteered to address fratricide, Deputy Chief of Staff for Personnel (DCSPER) LTG Thomas Carney offered to look within HSI/MANPRINT. The tasking given to Major Al Sciaretta of the HSI/MANPRINT Directorate was to come up with components that a new survivability domain would address, and upon study he proposed the following: 1) reduce fratricide, 2) reduce detection, 3) reduce the probability of being attacked, 4) minimize damage, 5) minimize injury, and 6) reduce physical and mental fatigue. These were accepted to be the components comprising the new domain, and the Chief of Staff gave his approval to form the new HSI/MANPRINT Domain of Soldier Survivability.

The task was passed down from Department of the Army through AMC and the US Army Research Laboratory (ARL), which chose ARL's Survivability/Lethality Analysis Directorate (SLAD) as the logical organization to work this new part of HSI/MANPRINT.

DCSPER's assignee to modify language of AR 602-2, staff the proposed changes for review throughout the Army, and get it signed was MAJ Mitchell Howell, who had served with the 101st Airborne division during Operation Desert Storm. From ARL's Human Research and Engineering Directorate (HRED), Dr Don Headley, with assistance provided by Rick Tauson and Bill Doss, were assigned to assist

SLAD in setting up the new domain and providing any tools. SLAD's assignee to chair and construct this new SSv domain was Richard Zigler. MAJ Howell, Dr Headley, and Mr Zigler formed the core of action officers responsible for providing structure to the new HSI/MANPRINT domain.

Briefings on the coming HSI/MANPRINT SSv domain were given in 1994 to officials in a number of Department of the Army acquisitions, Training and Doctrine Command (TRADOC), medical, and program manager (PM) organizations to gain support for the new domain. Team briefings on the HSI/MANPRINT SSv program by Major Howell, Dr Headley, and Mr Zigler were made to the following notables and many others:

- Deputy Under Secretary of the Army for Operational Research (Mr Walter Hollis)
- Headquarters Department of the Army (HQDA) DCSPER (LTG Thomas Carney)
- HQDA Assistant DCSPER (MG Arnold)
- Office of the Assistant Secretary of the Army (Research, Development, and Acquisition) Assessment & Evaluation (Dr Herbert Fallin)
- Office of the Secretary of Defense (OSD) HSI (Ms Pam Bartlett)
- CG US Army Armor School and Center (MG Larry Jordan)
- CG US Army Field Artillery School and Center (MG John Dubia)
- Deputy CG US Army Aviation School and Center (BG Charles Adams)
- CG US Army Chemical Center and School (BG Ralph Wooten)
- CG US Army Military Police Center and School (MG Alfonso Lenhardt)
- CG US Army Engineer Center and School (MG Joe Ballard)
- CG US Army Infantry Center and School (MG John Hendrix)
- DCSPER Director of Army HSI/MANPRINT (Dr Harold Booher)
- CG US Army Safety Center (BG Thomas Garrett)
- Director of ARL (Mr Richard Vitali)
- Commander Walter Reed Army Institute of Research
- Commander US Army Research Institute for Environmental Medicine

- Commander US Army Aeromedical Research Laboratory
- Multiple PMs

Dr Robin Keesee, Director of ARL/HRED, accompanied the briefing team to all briefings except one, where Dr Harold Booher substituted for Dr Keesee. Much was owed to Dr Keesee for making time available in his busy schedule.

A committee of 20 personnel from the HQDA HSI/MANPRINT Directorate, US Army Medical Research & Development Command (now renamed Medical Research & Materiel Command [MRMC]), and ARL was formed to make a list of survivability issues to form the base set of issues from which to initiate an SSv assessment (SSvA) of an Army program, whether it would be a helicopter, armored vehicle, missile and launcher system, communications system, etc. This list was then named by Dr Keesee to be the Parameter Assessment List (PAL). (The PAL was published by ARL/HRED and rated as Distribution Statement D: Distribution authorized to the Department of Defense (DoD) and US DoD contractors. Some distribution restrictions may apply to organizations outside of DoD.) A lot of work by ARL/HRED's Bill Doss and Rick Tauson was put into compiling and formatting the resulting 200 basic survivability issues, which is said to be the first official list of survivability issues in the Army (personal conversation in early 1992 with Frank Manion, Deputy Director of US Army Survivability Management Office, US Army Laboratory Command, Adelphi, MD. Mr Manion stated that there was no such list of survivability issues at that time, so the SSv PAL was the first. Unreferenced.), and possibly within DoD.

A memorandum of agreement arranging for MRMC support for MANPRINT SSvAs was negotiated by Mr Zigler in 1994. This was said to be the first cooperative agreement between MRMC and an element of the former US Army Ballistics Research Laboratory, as MRMC was reputed to have resisted cooperating with that lab.

The staffed language changes to AR 602-2 were approved and the SSv domain became effective on 7 October 1994.

Former chair Mr Zigler was appointed the Army point of contact (POC) for SSv, but responsibility for making it work within ARL/SLAD was instead granted by the director in January 1995 to the then 8 (now 3) SLAD mission area managers for their assigned acquisition category (ACAT) I and II programs.

The initial 3 organizational POCs were: LTC Charles Salter of MRMC's Operational Medicine Research Directorate located at Fort Detrick, MD, Dr Donald Headley of ARL/HRED, and Richard Zigler of ARL/SLAD.

3. Snapshot of HSI/MANPRINT SSv within Acquisition

3.1 Changes Since Any Previous Review

The first time the HSI/MANPRINT SSv domain was formally reviewed was during the Soldier Performance and HSI review conducted in Building 459 of Aberdeen Proving Ground (APG) during 8–10 July 2014. There have been no substantial changes to the domain and its efforts. The official memo for Army Regulation 602-2 was published 27 January 2015 changing the name of MANPRINT to HSI.³

3.2 US Air Force, US Navy, United Kingdom

Currently, the Air Force does not have a comprehensive HSI program similar to Army HSI/MANPRINT or Navy HSI. The US Marine Corps does not have a separate HSI program but uses Navy HSI.

Congressional language in 2003 and again in 2006 directed the Navy to adapt HSI/MANPRINT to their use and integrate this activity with ongoing force management initiatives. The Navy was to institutionalize and standardize HSI methodologies and modeling tools while completing a DoD-wide review of HSI implementation across acquisitions. The Navy's HSI Enterprise Approach fulfills congressionally mandated Navy HSI responsibilities in accordance with Chairman of the Joint Chiefs of Staff Instruction 3170 (series), DoD 5000 (series), and Secretary of the Navy Instruction 5000.2. HSI tools and analyses were integrated as a subset of systems engineering.

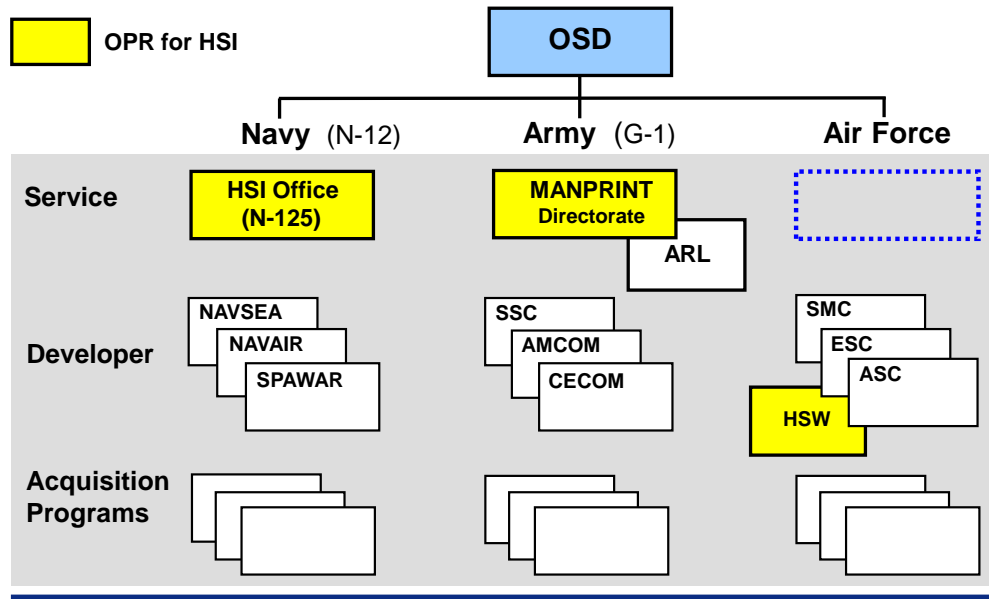
The Army's HSI/MANPRINT principals and POCs met on a number of occasions, briefed, and worked with the Navy in setting up its HSI program.

Figures 3–6 illustrate the organization, location, and overall picture of US military HSI.



U.S. AIR FORCE

HSI Organization and Leadership Inter-Service Comparison



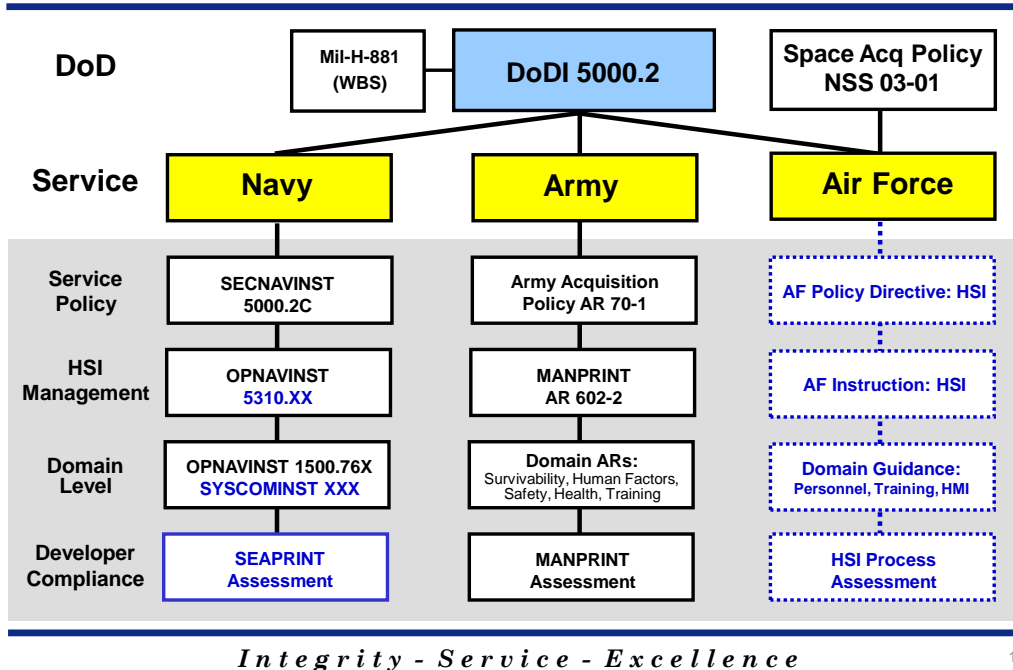
Integrity - Service - Excellence

16

Fig. 3 Organization and leadership of HSI in the OSD, Army, and Navy⁴



HSI Policy Flow-down Inter-service comparison



18

Fig. 4 Service policy flow-down through each service, with the thought that the Air Force would someday have their own full HSI/AIRPRINT program to stand with the Navy’s HSI and Army’s HSI/MANPRINT⁴



The Big Picture

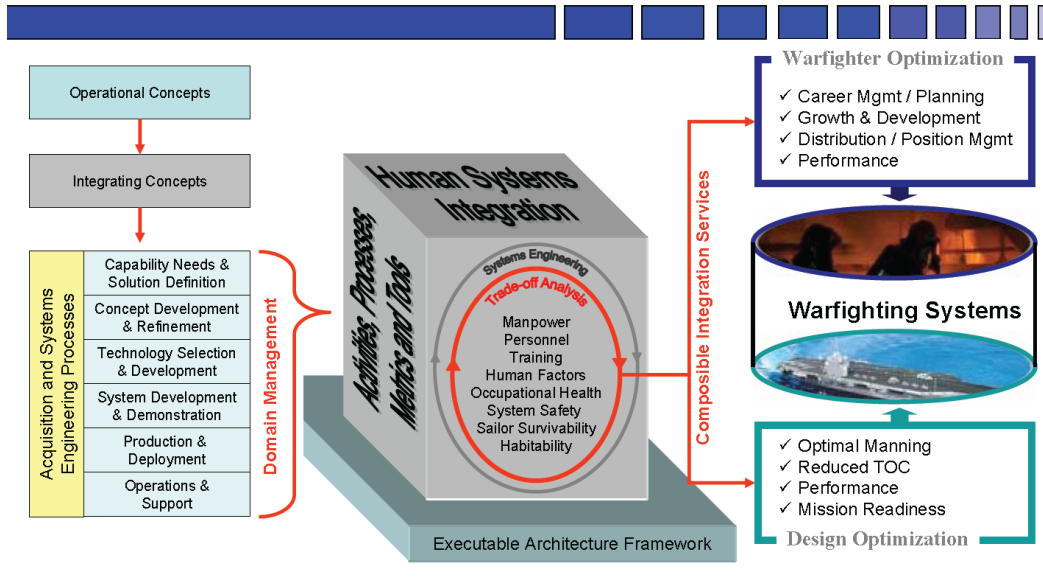


Fig. 5 US Navy's HSI big picture⁵

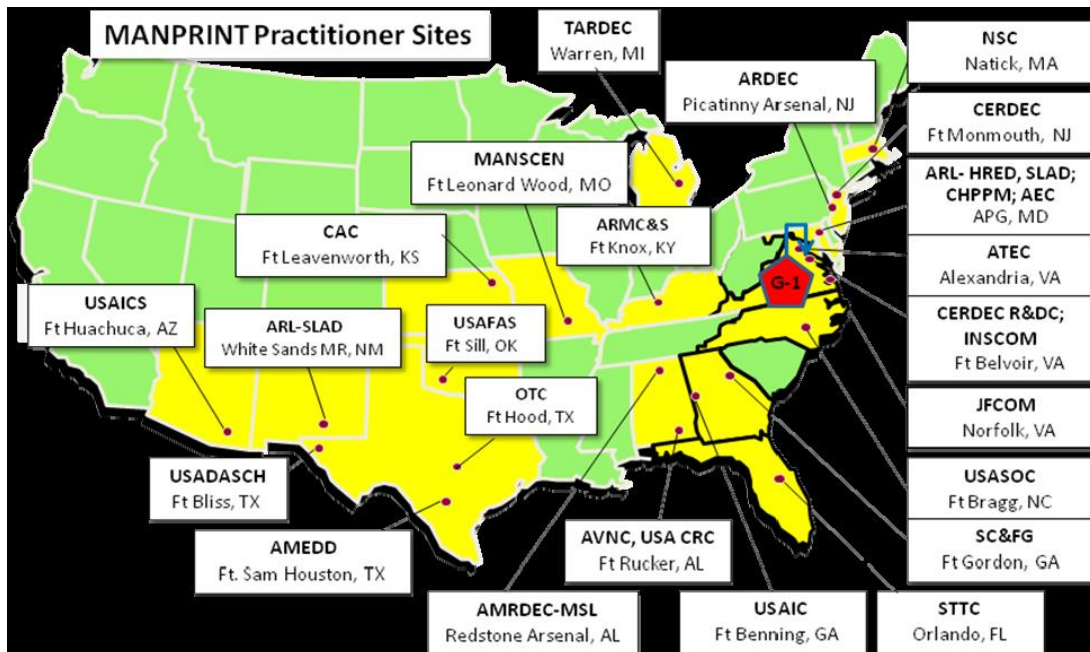


Fig. 6 MANPRINT practitioner sites^{6,7}

The United Kingdom's Ministry of Defence (MOD) employs Human Factors Integration (HFI) from its Defence Equipment and Support organization. The guidelines they follow are in Defence Standard 00-250 Human Factors for Systems Designers and Joint Services, Publication 912, Human Factors Integration for Military Systems. Their HFI is similar to DoD's HSI, and both developed from the Army's HSI/MANPRINT program:

The main differences between the two is that HFI has a Social and Organisational domain which tackles issues concerned with the organizational configuration, social environment and the ways of working in a Capability. Whereas, HSI has Survivability which looks at 'The characteristics of a system that can reduce fratricide, detectability and probability of being attacked and minimize system damage, Soldier injury and cognitive and physical fatigue.'

(email excerpt to SLAD's R. Zigler, dated 8 November 2013, sent by Ian Harryman, Human Factors Integration Policy, MOD, Abbey Wood, United Kingdom (UK); email forwarded to HQDA G-1 MANPRINT Directorate for the response. Unreferenced.)

Ms Melanie Forster initially led the UK MOD HFI program during the early 2000 time frame, working both in MOD Headquarters and the Defence Procurement Agency. She worked closely with MANPRINT Director Harold Booher, in setting up their HFI. The Army's HSI/MANPRINT POCs and principals had on a number of occasions also met, briefed, and worked with the representatives of MOD in setting up its HFI.

3.3 HSI/MANPRINT SSv Strategy and Program

ARL's role in the HSI/MANPRINT SSv is that of assisting Army PMs in their execution of the acquisition process by performing the function of generation and assisting in the resolution of survivability issues and in assessing these issues according to Army Regulation 602-2. ARL/SLAD is designated as the Army's SSv assessor for ACAT I and II programs with the support of ARL/HRED. Additionally, ARL/HRED's field element personnel are designated to perform SSvAs for ACAT III items.

ARL/SLAD generally performs ongoing assessments of SSv issues on about 50 large and small PM programs at any given time, with approximately 15 assessments and reports produced in support of milestone decisions during a year. ARL/HRED's field elements provide evaluation assistance to ARL/SLAD on each of the large ACAT I and II assessments and process yearly 10+ HSI/MANPRINT SSvAs on the ACAT III programs.

One ARL/SLAD individual is assigned duties as the Army's SSv POC, representing ARL, maintaining SSv visibility by speaking at HSI/MANPRINT and

HSI functions, performing coordination functions, training, guidance, and policy in support of major DoD ACAT I and II programs.

3.3.1 Strengths

3.3.1.1 Expertise

- ARL expertise in HSI/MANPRINT SSv issues and assessment is fairly substantial when senior personnel with a lot of related experience are the HSI/MANPRINT practitioners.
- The SSv PAL issues provide a substantial starting point for SSv evaluators, while providing a great deal of flexibility with the ability to add and subtract issues during the issue generation and resolution phases.
- The ARL field elements are an HSI/MANPRINT strength but have the potential to be stronger due to their on-site locations within the Army.

3.3.1.2 HSI/MANPRINT SSv Leadership

- AR 602-2 language designates ARL to perform the SSvAs.

3.3.1.3 Contacts

Twenty-one years of HSI/MANPRINT SSv existence and active involvement, plus customer contact with ARL/SLAD system leaders and ARL/HRED field element personnel, has yielded many official business contacts, word-of-mouth marketing contacts, and networking.

3.3.2 Weaknesses

3.3.2.1 Marketing

- As a business area, the SSv market size is mature, with little potential for increase.
- There has been a steady reduction in the number of major combat systems being developed, with few produced.

3.3.2.2 Staff

The work effort for multiyear programs of issue generation, assessment, and issue resolution requires constant attention over a multiyear-long time period by the HSI/MANPRINT practitioner(s).

Longer-term programs or projects are affected more by personnel changes in multiple organizations. As the years roll by, the practitioners, PMs and their staff members, and other organizations' personnel can change multiple times, which could lead to a lack of "corporate memory" when handled by a series of different evaluators. Or an individual evaluator's "burn-out" can occur due to the constant swirl of ever-changing personalities and organizations. For example, one program that ran during 1993–2007 experienced 6 PMs, multiple staff changes, 5 test manager changes, 5 Army Test and Evaluation Command (ATEC) System Team (AST) chairs, changing requirements due to the program mutating from a long-time ACAT III, to an ACAT II program, and then to an ACAT IC program with OSD interest in further expansions of documentation requirements, testing, and organization participations, etc. In this example, the only constant personalities were the HSI/MANPRINT SSv assessor and 2 of the PM contractor support staff.

3.4 Assessment Process

The SSv domain was established to assist materiel developers, combat developers, evaluators, and decision-makers. The 6 SSvA components are displayed in Fig. 2.

An important concept to retain during assessment is that the primary difference between SSv and the other HSI/MANPRINT domains is that SSv addresses issues involving enemy and friendly combat weapons–induced injuries and platform damage as well as the inherent hazards to humans under threat/combat conditions. Under normal noncombat environment operating circumstances, some related issues would be considered to also be within the realms of the Human Factors Engineering, Systems Safety, and Health Hazards domains of HSI/MANPRINT. Domain assessors (both Army and contractor) should attempt to assist each other in issue recognition and resolution for the maximum benefit to be obtained and applied for a program.

The PAL is a tool that provides a common starting point but maintains a flexible structure and content for an SSvA of a system. It is based on a list of issues that describe a developmental system's impact on SSv. The format guides the assessor into establishing a somewhat systematic path of investigation that address most issues, allowing the evaluator(s) to present the system's effect on SSv in reasonably objective terms. The PAL contains 200 SSv issues related to survival of the Soldier and his/her equipment during combat, but it is flexible in that assessors may add or delete issues to tailor the PAL to a specific system and its technical characteristics. The PAL was developed to aid a multidisciplinary approach using a number of subject matter authorities. A thorough familiarity of program-relevant SSv issues is necessary to do a competent job during the life of the program.

In the SSv domain, it is assumed that the Warfighter is integral with his or her equipment during combat. Although personnel and equipment appear to be separate areas, in the real world they both fight together as a single intertwined unit, and this dictates that they be evaluated together. Damage to equipment due to an enemy or fratricide action may endanger the Warfighters' well-being and put them immediately into a life-threatening situation. The effects on the equipment are evaluated to determine potential additional effects on the personnel manning the specific system.

Figure 7 shows the decision point where materiel development would start, with HSI/MANPRINT activity intended to start with participation in the construction of the TRADOC Initial Capabilities Document (ICD) and actively participating through the yellow, blue, and finally to the orange/salmon acquisition phases. One of the subtle points of this chart is that a program may enter the acquisition materiel development process directly at any of the 3 major milestones (A, B, or C). For example, a Materiel Development Decision can be made, followed by the materiel development process at Milestone C to obtain approval to go directly into production or purchase, thereby ignoring the Technology Development Phase and the Engineering and Manufacturing Development Phase. In this very abbreviated situation, HSI/MANPRINT can do very little, if anything, other than possibly inspect the equipment and write a report of any findings.

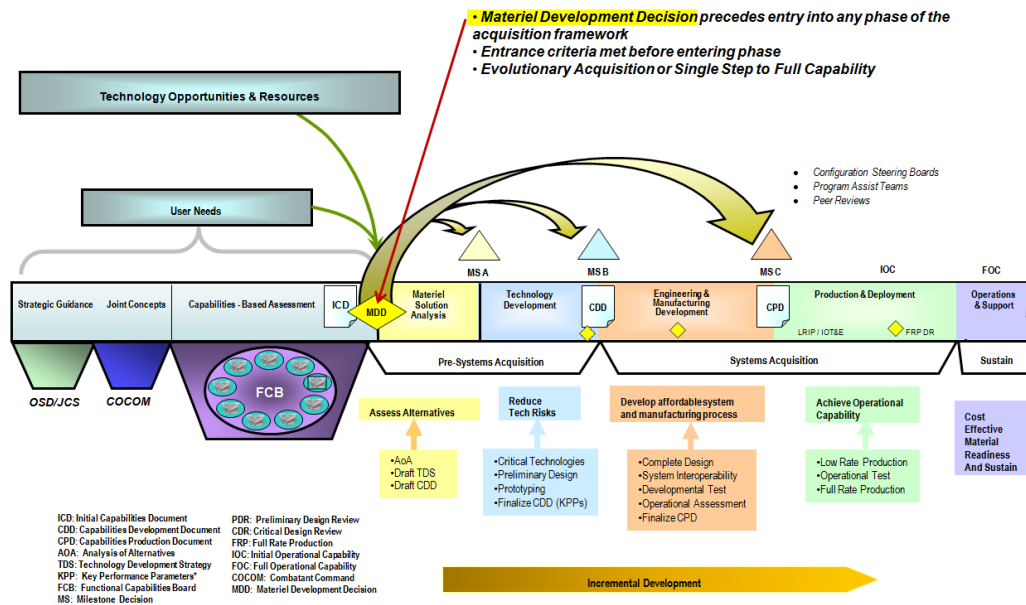


Fig. 7 The Defense Acquisition Management Framework⁸

Figure 8 shows the types of efforts performed by HSI/MANPRINT assessors during a program, with the blue-dashed arrows showing where the generation and resolution of HSI/MANPRINT issues would occur. This generation and resolution of design issues is intended to be a continuous effort during the life of a program and not just a snapshot of time used to write a report(s) for submission in support of a major acquisition milestone. This is a portrayal of a program going through all the phases of the full acquisition process. (The Engineering and Manufacturing Development and Demonstration Phase title was reduced to Engineering and Manufacturing Development Phase after Fig. 8 was created.)

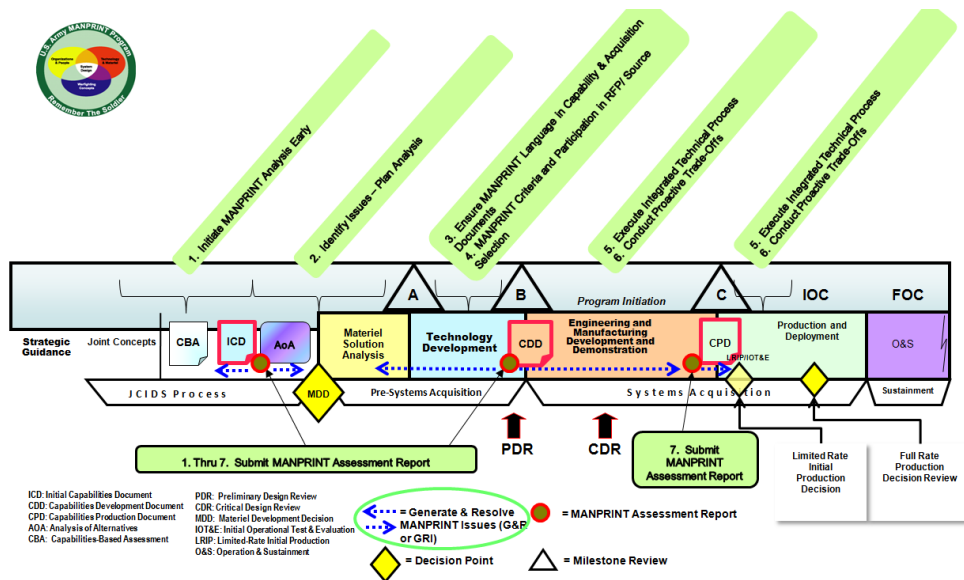


Fig. 8 Defense Acquisition Management System Life Cycle and HSI/MANPRINT process steps⁸

The bold outlined area at the top of Fig. 9 portrays the amount of impact on a design that HSI/MANPRINT work in each area could potentially have. This is broken out by activity and by acquisition phase. When a major program goes through the full acquisition process, the impact can be less or more, but the bold area will portray where the HSI/MANPRINT evaluator should plan to expend the most effort to have the most impact, which should be in the Technology Development phase after the contract award is made. The contractor HSI/MANPRINT team(s) must insert the issue considerations into their program design(s) as best they can during the proposal build process. After the Source Selection Evaluation Board, both the Army and the contractor HSI/MANPRINT team(s) jointly work on the generation and resolution of issues to help produce the best possible design for the Soldier. This phase is both the most important and the most dynamic in that a number of design iterations and improvements will be made in rapid succession, slowing down more and more when approaching Preliminary Design Review and especially the Critical

Design Review. After these 2 design reviews, the design will become fairly firm so the other parts of the contract(s) can be performed and completed. Most of the modeling and simulation, developmental testing, live-fire testing and evaluation, and analysis generally occurs in the following Engineering and Manufacturing Development and Demonstration Phases.

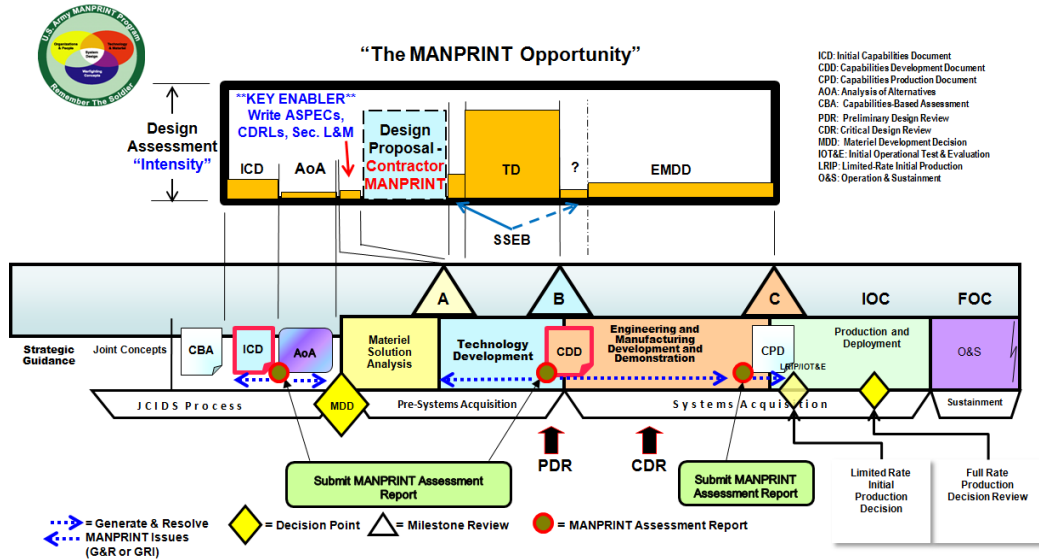


Fig. 9 Times of maximum opportunity to positively affect a design⁸

A key action to be taken by the HSI/MANPRINT coordinator is to insert language into contract Sections L and M (from Cheryl Burns, Fort Knox Field Element, ARL/HRED):

- Critical areas MANPRINT needs to impact to affect a program.
- Write specifications incorporating MANPRINT principles; the Contract Data Requirements Lists (CDRLs) and Sections L and M must back up the specifications. This must be done to enable the Army’s MANPRINT representatives to have leverage and power to influence the program’s design(s). (Surprisingly, this enabling will carry over to the contractor’s MANPRINT personnel, who can use this power to influence their management to pay more attention to their issues and to resolve these more vigorously.)
- Embed language in the contract at the very beginning, as the PM will not add things back into the contract due to cost to change the contract. Acquisition specifications (ASPECs) need to be specific, concrete, and testable to be enforced, not just one vague statement about MIL-STD-1472 Rev. G (DoD Design Criteria Standard: Human Engineering), although that should also be there to cover unexpected design issues.

The area in bold outline at the top of Fig. 10 portrays the amount of flexibility that a design will have over time as the acquisition process and the corresponding contract(s) play out. This is broken out by activity and by acquisition phase. Do not expect that design changes will be easily made nor accepted during the Engineering and Manufacturing Development and Demonstration Phase, as schedule and cost will become paramount to both the contractor team and to the PM and his/her staff.

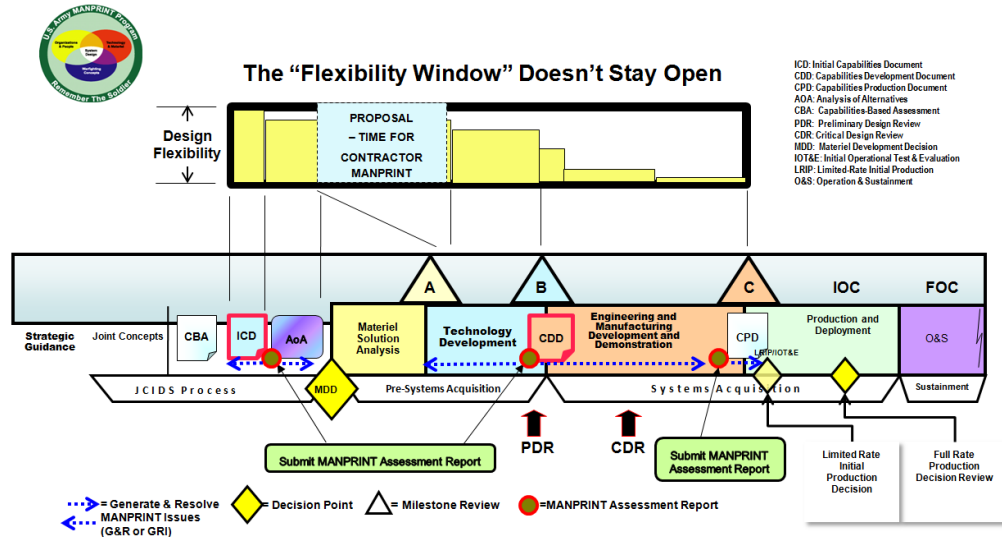


Fig. 10 Design flexibility declines over time⁸

A majority of design decisions will be influenced by the capabilities stated in TRADOC’s ICD. By the time a program is in its Material Solution Analysis Phase, 70%–75% of the cost-related decisions have already been made. For example, once the decision is made between wheels and tracks for an armored vehicle’s mobility, a large part of the vehicle design is already influenced. Similarly, once the decision is made between a fixed- and rotary-wing aircraft, many design decisions are already made. In the Technology Development Phase, 85% of the cost-related decisions have been made, and in the Engineering and Manufacturing Development and Demonstration Phase, 90%–95% of those decisions have been made.

A further consideration is that once the contractor(s) is in the design process, and once a design decision is made on a part or mechanism, it costs time and money to change, as a number of design decisions will have been made by the time an alternate decision is made to change to a different design (see Fig. 11). This will involve undoing a number of design decisions made since that initial design was approved. The driving force for a HSI/MANPRINT assessor must be to evaluate new designs as quickly as possible to minimize the number of design decisions that must be undone and then remade with resultant schedule delays and cost increases.

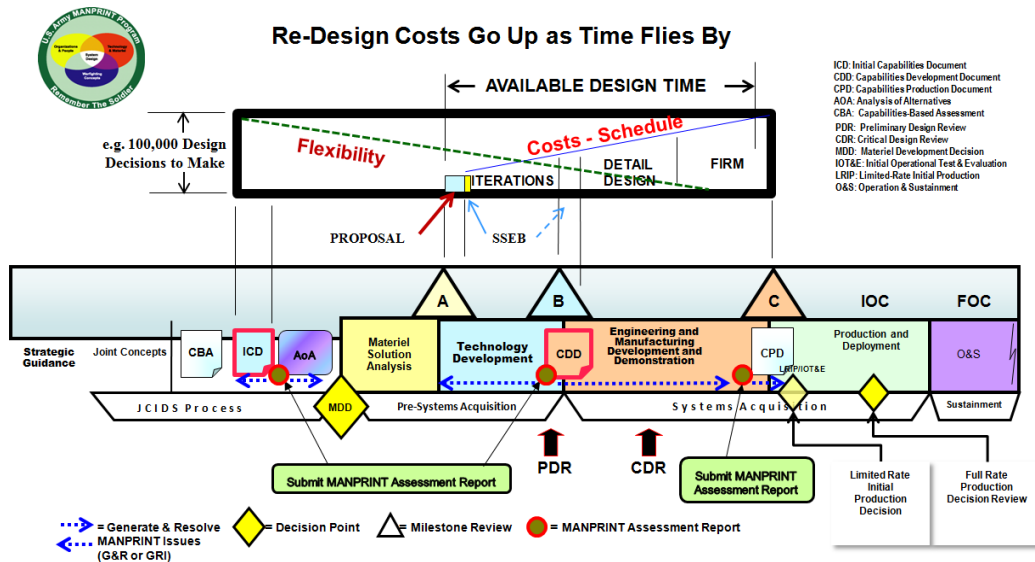


Fig. 11 Redesign flexibility, funding availability, and schedule dissipate together⁸

Sometimes rapid programs are put together due to special need, and thus different acquisition phases will be bypassed. A representation of a real program that was worked on is shown in Fig. 12, including the materiel decision, the acquisition strategy decided, and the acquisition process at Milestone C (a real-life example of Fig. 7, where the decision was made to go from the Materiel Development Decision directly to Milestone C, intentionally bypassing the yellow, blue, and salmon acquisition phases), which is the decision to purchase. The program described was categorized as a rush program, with only 2 units being purchased. One was demonstrated at a test range, and both were immediately fielded. The PM was granted the flexibility to accomplish the purchase in a desired short time period, which was accomplished. During this type of acquisition, very little if any HSI/MANPRINT impact was made to the design, as there was no time available to do so.

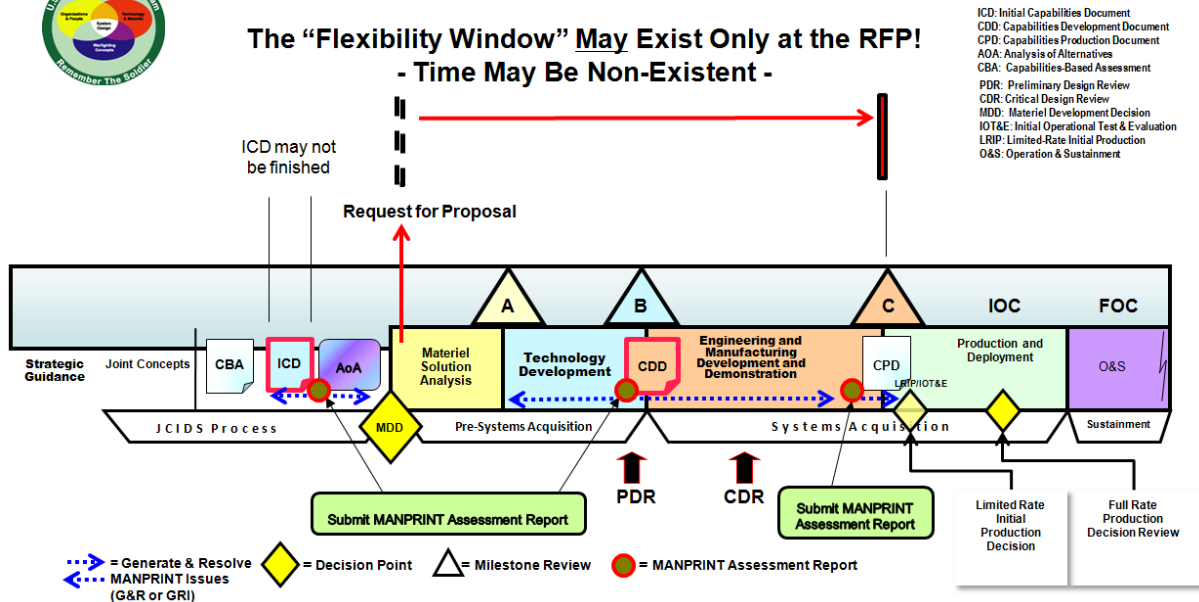


Fig. 12 Rapid equipping of the force; design flexibility⁸

The potential documents that may be involved in an assessment are shown in Table 1, which lists required documents for ACAT I and II major Milestone Decision Reviews. The colored oblong items of interest are there to assist in pointing out which documents may assist the assessors in doing their work. When an SSvA is requested, the first step is to determine the initial set of issues to be used per the ICD, set aside the remaining PAL issues, and then assign Required System Performance (RSP) criteria for each applicable issue. These criteria should result from consensus among the SSv assessors, the PM, and the user community. Sources of RSP levels may come from TRADOC capabilities documents, the system’s concept of employment, threat documentation and experimental data, and the evaluation by subject matter experts. System performance requirements for each of the SSv issues should be realistic, measurable, and sufficient to provide a reasonable chance of survivability in the expected mission environment.

Table 1 Requirements for milestone decision reviews⁹

Requirement	Milestone/Decision Point					
	MDD	A	B	P-CDRA	C	FRP
Acquisition Decision Memorandum ⁵	X	X	X	X	X	X
Acquisition Program Baseline ⁵			X		X	X
Acquisition Strategy ⁵ (see Page 5)			X		X	X
Acquisition Information Assurance Strategy (all IT incl NSS)		X	X		X	X
Affordability Assessment			X		X	
Alternate LF T&E Plan (programs with waiver from full-up LFT&E) ²			X			
Analysis of Alternatives (AoA) ^{3,5}		X	X		X	X
AoA Study Guidance	X					
Benefit Analysis & Determination ^{1,8} (bundled acquisitions)			X			
Beyond LRIP Report ² (incl MDAPs that are also MAIS)						X
Capability Development Document (CDD) ⁵			X			
Capability Production Document (CPD)					X	
Clinger-Cohen Act (CCA) Compliance ^{5,7}		X	X		X	X
Competition Analysis ^{1,8} (depot-level maintenance rule)			X			
CIO Confirmation of CCA Compliance (DoD CIO for MAIS and MDAP)		X	X		X	X
Component Cost Estimate ^{5,9} (MAIS; optional MDAP)		X	X			X
Consideration of Technology Issues (MDAP & MAIS)		X	X		X	
Cooperative Opportunities ¹		X	X		X	
Core Logistics/Source of Repair Analysis ^{1,8}			X		X	
Corrosion Prevention Control Plan ¹			X		X	
Cost Analysis Requirements Description ^{5,9} (MDAP & MAIS)			X		X	X
Data Management Strategy ¹ (MDAP, MAIS & ACAT II)		X	X		X	X
Economic Analysis (MAIS) ⁷ (may be combined w/AoA at MSA)		X	X			X
Exit Criteria ⁵		X	X		X	X
Industrial Base Capabilities ¹ (MDAPs only)		X	X		X	
Independent Cost Estimate (ICE) ^{5,10,15} (MDAPs only)		X	X		X	X
Independent Technology Readiness Assessment ¹¹			X		X	
Information Support Plan ¹⁵			X	X	X	
Initial Capabilities Document (ICD) ^{4,5}	X	X	X		X	
Initial Operational Test & Evaluation Completed (ACAT I & II)						X
Item Unique Identification (IUID) Plan (Part of SEP)		X	X		X	
Joint Interoperability Test Certification (IT & NSS)						X
Life-Cycle Signature Support Plan ⁵		X	X		X	
Life-Cycle Sustainment Plan ¹			X		X	X
LF T&E Waiver ² (covered systems) (n/a MAIS)			X			
LF T&E Report ² (covered systems) (n/a MAIS)						X

ICD =>

Table 1 Requirements for milestone decision reviews⁹ (continued)

Requirement	Milestone/Decision Point					
	MDD	A	B	P-CDRA	C	FRP
LRIP Quantities MDAP & ACAT II (n/a AIS)			X			
Manpower Estimate (MDAPS only) ⁵			X		X	X
Market Research		X	X			
Milestone Decision Authority (MDA) Certification (MDAPs only) ⁴		X	X		X	
MDA assessment of chem, bio, rad, and nuc survivability			X		X	
Military Equipment Validation ¹					X	X
Net-Centric Data Strategy ^{5,12}		X	X		X	
Operational Test Agency Report of OT&E Results			X		X	X
Preliminary Design Review (PDR) Report ¹⁶			X			
Post-Critical Design Review (CDR) Report				X		
Post Implementation Review						X
Program Protection Plan (PPP) ¹		X	X		X	
Prog Environment, Safety & Occup Health Evaluation (PESHE) ⁵			X		X	X
Replaced System Sustainment Plan ⁵ (MDAPs only)			X			
Selected Acquisition Report (SAR) ^{4,13}						
Spectrum Supportability Determination ⁸			X		X	
System Threat Assessment (STA) (ACAT II) ^{5,14}			X		X	
System Threat Assessment Report (STAR) (ACAT I) ^{5,6}			X		X	
Systems Engineering Plan (SEP)		X	X		X	
Technology Development Strategy (TDS)		X	X		X	
Technology Readiness Assessment (TRA) ⁵			X		X	
Test & Evaluation Master Plan (TEMP)			X		X	X
Test & Evaluation Strategy (TES)		X				

- = Item or Area of Interest**
- ¹Part of TDS or Acquisition Strategy
 - ²OSD T&E Oversight Programs
 - ³MDAP: A,B,C; MAIS: A, B, FRP
 - ⁴Milestone C if Program Initiation
 - ⁵Program Initiation for Ships
 - ⁶Validated by DIA for ACAT ID; AIS use DIA validated capstone info/ops Threat Assessment Decision
 - ⁷Milestone C if equivalent to FRP
 - ⁸Milestone C if no Milestone B
 - ⁹MAIS whenever an economic analysis is required
 - ¹⁰May be CAIG Assessment at Milestone A
 - ¹¹ACAT ID only if required by DDR&E
 - ¹²Summarized in TDS; details in ISP
 - ¹³SAR at program initiation; annually thereafter
 - ¹⁴Validated by Component; AIS use DIA validated capstone info/ops Threat Assessment Decision
 - ¹⁵MDA may request cost assessment at Milestone A
 - ¹⁶If PDR is after Milestone B, MDA will conduct a post-PDR assessment review

DoDI 5000.02

**Tables from Defense Acquisition University “Program Managers Tool Kit”,
16th Edition (Ver. 1.0), January 2011, William Parker
Internet: <http://bookstore.gpo.gov/> Phone: 202-512-1800**

The timeliness of recognizing an issue and attempting to resolve it before many days have passed from the calendar date of when the design decision was made is absolutely essential to the contractor’s design teams and the PM. Timeliness will reduce design costs and help maintain schedules. This constant attention paid to designs and their progress is where HSI/MANPRINT and its domains can provide the greatest value to programs.

General steps in SSv evaluation:

- Select potential issues from the PAL.
- Select actual issues to pursue.
- Resolve as many issues during each acquisition phase as you can.
- Add new issues as appropriate.
- Review issues periodically during each acquisition phase.
- Meet with POCs of interested organization to review issue status for completeness and assign severity rating to each issue.
- Prepare report for support of Milestone B or C.
- Forward report for review by PM, and then upward through HRED to the HQDA G-1 MANPRINT Directorate.

The PAL provides a basic list of some 200 issues for a system to be assessed against. Those issues that do not apply are discarded or marked as nonapplicable as appropriate. The language of a number of issues will be modified to more accurately address the program design being assessed. New or more-specific issues are added to the list as they are discovered, and attempts are made to resolve most or all issues at the soonest opportunity.

Tables 2–6 detail SSv evaluation criteria.

Table 2 SSv severity rating definitions¹⁰

Description	Category Code	Definition
Life Threatening /Death	I	A system characteristic that, if not remedied, is considered serious enough to prevent the fielding of the system. This characteristic could result in death of the Soldier/Marine, abortion of the mission, or loss of the system.
Serious	II	A system characteristic that, if not remedied, could result in serious bodily injury or death to the Soldier/Marine, reduced mission performance, extensive system damage, serious diminished capacity of the system to perform its intended mission, or a significant negative impact on the manpower, personnel, or training requirements of the system. Characteristics that can be expected to result in death of the Soldier/Marine, abortion of the mission, or loss of the system may be considered major if the frequency of occurrence is considered remote or improbable.
Mild	III	A system characteristic that, if not remedied, could result in serious bodily discomfort to the Soldier/Marine, reduced operational effectiveness, system damage, or a negative impact on the manpower, personnel, or training requirements.

Table 2 SSv severity rating definitions¹⁰ (continued)

Description	Category Code	Definition
Negligible	IV	A system characteristic that, as the system is currently proposed for fielding, will not have any negative effect on Soldier/Marine survivability. This includes characteristics that improve Soldier/Marine survivability.
Not Applicable	NA	A characteristic that cannot reasonably be applied to this system.

Note: Red = critical, yellow = major, and green = minor.

Table 3 SSv probability criteria¹¹

Description	Level Code	Probability Criteria
Frequent	A	Likely to occur frequently.
Probable	B	Will occur several times in the life of an item.
Occasional	C	Likely to occur sometime in the life of an item.
Remote	D	Unlikely but possible to occur in the life of an item.
Improbable	E	So unlikely that it can be assumed that the occurrence may not be experienced.

Table 4 SSv risk levels¹²

Soldier/Marine Survivability Risk Levels						
		Critical	Serious	Mild	Negligible	
Frequency of Occurrence		I	II	III	IV	Not Applicable
Frequent	A	I-A	II-A	III-A	IV-A	NA
Probable	B	I-B	II-B	III-B	IV-B	NA
Occasional	C	I-C	II-C	III-C	IV-C	NA
Remote	D	I-D	II-D	III-D	IV-D	NA
Improbable	E	I-E	II-E	III-E	IV-E	NA

Note: Red = critical, yellow = major, and green = minor.

The assessment or comparison of the required and the actual system performances lead to a rating for each issue. An issue may be assigned a deficiency rating of “Critical,” “Major,” “Minor,” “None,” or “Does Not Apply.” The rating will be assigned based on the magnitude of the difference between required and actual performance and/or the potential effect on injury to the Soldier, mission completion, loss of the system, or inability of the system to complete its mission. A final SSv rating for the system is based on the most severe of the component ratings. An issue rated as Critical, where a Soldier has a strong probability of being killed through use of a piece of equipment, can merit the component rating and the overall system rating as Critical or Red. Critical or Major deficiencies must have accompanying written explanations. The initial set of system issues is very generic

in support of Milestone A, but as the concept becomes more firm approaching Milestone B, the SSv issues will become more specific and relevant to the system being assessed.

The platform concept was generally in good form during the company's proposal, and firmed up during the Preliminary Design Review of the Technology Development phase, with most design decisions having been made by the time of the Critical Design Review early in the System Development and Demonstration (currently renamed as "Engineering and Manufacturing Development and Demonstration") phase of the acquisition process. A great deal of HSI/MANPRINT design evaluation work should be performed during these 2 acquisition phases in the resolution of issues with the PM staff and the contractor team, research of technical aspects, testing, familiarization with system design and technical capabilities and operation, and preparation for contractor and developmental testing. Along with the formalized HSI/MANPRINT and SSv activities, there will be an activity called "survivability analysis" (these are the additional technical investigations and analyses that ARL/SLAD's branches sometimes perform for a major program) that will cover many technical facets of this phase that may contribute to the system design and simultaneously provide for resolution of a number of SSv issues as time passes.

Issue resolution efforts are to be constantly worked during each program acquisition phase. An attempt must be made to resolve all issues by the end of Milestone C. Those that are still open at the end of each milestone are to be raised in the SSv Assessment Report, along with the written record of those that were closed. PM decisions to not address issues should be reported as such along with the rationale if available.

Sources of information on system performance may include modeling output, performance from similar or predecessor systems, engineering plans, task analysis and crew workload data, texts, research, and test data. During an early program milestone, the responses to potential issues may constitute best guesses, with more substantive information becoming available later in the life cycle. Information sources should be cited and critical data attached to the completed assessment report.

Record all findings for each issue, and for issue resolutions. This material contributes to the SSv Assessment Report. The resolutions of issues show progress to PM management, so be certain to maintain a record of these occurrences.

Survivability analysis is a process that evaluates equipment and personnel susceptibility to attack and physical injury. It focuses on the effects of threats that might reduce the ability of a friendly system to complete its mission. Part of the

survivability analysis determines if a potentially destructive action (i.e., bullet, fragment, high-powered energy device, chemical/biological agent, environmental situation, lightning, etc.) can affect the system and to what extent.

For good investigations to occur, a number of different disciplines are required. A good personnel survivability assessment can bring together a medical combat care provider, subject matter expert on electronic warfare, toxicologist, physiologist, human factors professional, a number of materiel developer personnel, and more. They may all be needed to make one integrated, threat- and combat-oriented HSI/MANPRINT assessment.

Based on the results of the SSvA, the assessors complete one of 2 report formats. A full SSv Assessment Report summarizes the assessment findings. The full report provides 1) an executive summary, 2) list of the data sources used, (3) data voids, (4) positive aspects of SSv in the system development, (5) any SSv deficiencies, grouped by Critical, Major, and Minor ratings, and (6) conclusions and recommendations. If there are no SSv issues for a system, a one-page abbreviated report is completed. The approved SSv Domain Report is then sent to the PM, TRADOC's capabilities manager, ATEC's Army Evaluation Center, the HQDA HSI/MANPRINT director, and to the designated ARL/HRED HSI/MANPRINT coordinator for compiling all domain assessment reports.

Personnel survivability is treated as an important part of Army acquisition by HSI/MANPRINT. This HSI/MANPRINT SSvA assists in providing coverage and assurance that issues will be, or are being, addressed in such diverse areas as electronic warfare, nuclear biological and chemical survivability, individual ballistic protection, directed-energy weapons, smoke/obscurants and atmospheric effects, physiological effects, and heat stress. Survivability work performed on a program can immediately be incorporated into addressing the SSv issues and efforts.

4. Programs and Funding Sources for Current HSI/MANPRINT SSvA Efforts

4.1 Customer-Funded Efforts

HSI/MANPRINT SSvAs are primarily customer-funded, although SLAD has funded a few small or partial assessments. During the fiscal years 2012 through 2014 (FY12–14), the SSvAs and transmittal letters to the MANPRINT assessments were provided for the following programs:

- Family of Weapon Sights-Individual (FWS-I): SSvAs were conducted on 2 vendor FWS-I devices during 2014 to support the FWS-I Milestone C decision. SSvAs were conducted on 2 vendor FWS-I devices April–June 2013 to support the FWS-I Milestone B decision (customer/mission-funded).
- Ground Combat Vehicle (GCV): Two draft SSv Assessment Reports of approximately 60 pages each were being finished in support of Milestone B when word was received to stop work on all Milestone B documentation (2010–2014, mission/customer-funded).
- FY14, Excalibur Precision Engagement Projectiles in support of Full-Rate Production (FRP) decision (signed 20 March 2014).
- FY14, Precision Guidance Kit (PGK).
- Terminal High-Altitude Area Defense (THAAD), FY10–17, for Materiel Release Reviews 3–6; ongoing until 2017 and beyond (customer-funded). Findings: Chemical, biological, and radiological (CBR) survivability was not established in detail during the Materiel Release Review 2 in 2010. Action has been corrected and detailed CBR procedures are emplaced.
- Patriot PAC-3 Missile Segment Enhancement FRP (no dates for milestone yet; customer/mission-funded); ongoing; no dates given. Schedules were briefed at the 2014 MANPRINT Working Integrated Product Team (WIPT) meeting at Fort Sill, OK. System is being upgraded through various “builds;” therefore, findings are not final and/or determined. Some have been documented with a test incident report and need further real-time evaluation.

- Integrated Air and Missile Defense, Milestone C, fourth quarter (4Q) FY15 (mission-funded): Vehicle survivability reviewed, selection, and path forward; combat identification methodology and electromagnetic interference (EMI) evaluated.
- OH58F Cockpit and Sensor Upgrade, Milestone C, 3QFY15 performed for the Milestone B in 2010 and continued for the Milestone C 3QFY15. Program terminated in March 2014 by Deputy Secretary of Defense (customer/mission-funded). Findings: Ballistic and nonballistic survivability addressed early in the prototype; fairly high aircrew situational awareness of battlefield elements such as locations of enemy units, friendly units, and route information; partial compliance for ingress/egress.
- Biometrics Enabling Capability, Increment 1, 2QFY15: ongoing; potential SSv issues are related to mainly Information Operations (IOs) and Computer Network Operation (CNO) (customer-funded). (Milestone might be delayed due to general program schedules.)
- Joint Personnel Identification, Version 2, 1QFY15 (customer funded). Potential SSv issues are related to mainly IOs and CNO. (Milestone might be delayed due to general program schedules.)
- FY14, Armored Multi-Purpose Vehicle (AMPV); draft (work done on mission funds and will be reimbursed with customer funds); draft report under review at the Project Management Office (PMO).
- FY14, Stryker Engineering Change Program; draft report under review at the PMO (work done in FY14 on mission funds and will be reimbursed with customer funds in FY15).
- FY14–15, Joint Lightweight Tactical Vehicle (JLTV) SSvA for Milestone C; Milestone B SSvA signed 20 January 2012.
- FY12–FY14, Joint Air to Ground Missile (JAGM) system, supporting a Milestone B decision 3QFY15 (customer-funded).
- FY11–14, Air Soldier System.
- FY13, M1200 Targeting Under Armor (TUA) Fire Support Vehicle until cancellation 31 January 2012.
- FY10–12, Human Availability Techniques for Paladin (joint program with HRED and SLAD).
- FY13, XM1156 PGK (signed 3 December 2012).

- FY13, M109 Family of Vehicles (FOV) Paladin Integrated Management (PIM) Program for the M109A6 PIM and M992A2 PIM vehicles (signed 11 March 2013); FY10–12, Human Availability Techniques for Paladin (joint program with HRED and SLAD).
- Enhanced Night Vision Goggle (ENVG) II: SSvAs were conducted November 2011–March 2013 to support the ENVG II FRP decision; SSvAs conducted on 4 different variants of the ENVG system (mission/customer-funded).
- Joint Effects Targeting System (JETS) Target Location Designation System (TLDS): An SSvA was conducted September–November 2012 to support the JETS TLDS Milestone B decision (mission/customer-funded).
- FY12, Excalibur (XM982 projectile, 155-mm, high explosive) (signed 21 August 2012).
- FY10–12, Human Availability Techniques for Paladin (joint program with HRED and SLAD).
- FY08–12, Ground Soldier System/NETT Warrior.
- Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System, Milestone C, 4QFY12 (customer/mission-funded); Mission Oriented Protection Posture-4 compatibility issues and lack of CBR decontamination procedures.
- FY06–11, Mounted Soldier System for the Milestone-C decision. SLAD worked with US Army Center for Health Promotion and Preventive Medicine on SSv issues in FY10.

4.2 Mission-Funded Efforts

With mission funding, the following recent ARL documents were published:

- Kaufman MB. *Soldier/Marine Survivability Assessment for the Joint Light Weight Tactical Vehicle (JLTV) in Support of Engineering and Manufacturing Development and Demonstration Decision*. Aberdeen Proving Ground, MD: US Army Research Laboratory; 2011 Dec. Report No.: ARL-SR-234.
- Kaufman MB. *Soldier/Marine Survivability Assessment for the M1128 Stryker Mobile Gun System (MGS) in Support of a Production Decision*. Aberdeen Proving Ground, MD: US Army Research Laboratory; 2011 Dec. Report No.: ARL-SR-235.

- Kaufman MB. *Soldier/Marine Survivability Assessment for the M1135 Stryker Nuclear, Biological, Chemical Reconnaissance Vehicle (NBCRV) in Support of a Production Decision*. Aberdeen Proving Ground, MD: US Army Research Laboratory; 2011 Dec. Report No.: ARL-SR-236.
- Kaufman MB. *Soldier/Marine Survivability Assessment for the M982E1 Excalibur Precision Engagement Projectile in Support of Milestone C Decision*. Aberdeen Proving Ground, MD: US Army Research Laboratory; 2012 Dec. Report No.: ARL-SR-256.
- Kaufman MB. *Soldier/Marine Survivability Assessment for the M1200 Targeting Under Armor (TUA) Fire Support Vehicle in Support of Milestone C Decision*. Aberdeen Proving Ground, MD: US Army Research Laboratory; 2012 Dec. Report No.: ARL-SR-257.
- Kaufman M. *Soldier/Marine Survivability Assessment for the XM1156 Precision Guidance Kit (PGK) in Support of Milestone C/Low-Rate Production Decision*. Aberdeen Proving Ground, MD: US Army Research Laboratory; 2013 Feb. Report No.: ARL-SR-260.
- Kaufman M. *Soldier/Marine Survivability Assessment for the M109 Family of Vehicles (FOV) Paladin Integrated Management (PIM) Program for the M109A6 PIM and M992A2 PIM Vehicles in Support of Milestone C Decision*. Aberdeen Proving Ground, MD: US Army Research Laboratory; 2013 Dec. Report No.: ARL-SR-270.
- Sense through the wall (STTW) FRP, 4QFY12; completed for the FRP (memo only). Findings: lithium ion batteries, when punctured, become hot and emit smoke; the STTW casing contains composites, plastics, metals, and sealants when combusted and produce toxic vapors; high case temperature can exceed the safe handling; Soldiers should wear gloves.

5. Some Significant (Unrestricted and Unclassified) Technical Achievements/Findings by HSI/MANPRINT SSv

The following is a partial list of accomplishments or findings of note during HSI/MANPRINT SSvAs.

5.1 Ground Combat Vehicle (GCV)

Addition of commander's independent weapon station to the GCV Infantry Fighting Vehicle and almost 180° defensive fire from the axis of the primary weapon and coaxial machine gun by HSI/MANPRINT SSv assessor R Zigler.

5.1.1 Defensive Fire: System’s Ability to Actively Prevent or Deter Attack

- <http://www.strategypage.com/dls/articles/20030912.asp>; accessed on or after 12 September 2003 and re-verified 8 May 2015.
- Unclassified after action report “SUBJECT: Operation Iraqi Freedom After Action Review Comments” from Iraq, 24 April 2003.
- Issue: Lack of a Bradley commander weapon system.
- Discussion: During the conduct of urban operations by this unit, due to limited visibility within the turret and the threat encountered not only from the front but from both flanks of the vehicles, Bradley commanders were required to expose themselves outside of the turret to acquire enemy forces, to control movement, and protect their own vehicles.
- TM C/3-15 Infantry, Task Force 1-64 Armor “Desert Rogues” during “Operation Iraqi Freedom”.

5.1.2 Steps Followed to Mitigate the Issue for GCV Program

- 1) “Socialized” the issue via HSI/MANPRINT assessments and ARL/SLAD Qualitative Vulnerability Assessment briefings (Future Combat System).
- 2) Proposed a capability with rationale via GCV Joint Capabilities Integration Development System (JCIDS) process for the ICD with TRADOC and ARL/HRED’s C Burns, who was working directly with TRADOC writers.
- 3) Up to 180° fire from primary weapon accepted by TRADOC capabilities manager into ICD.
- 4) PM’s office (ASPECs/production specifications) and contractors (designs) devised and implemented a solution.
- 5) Impact: addition of commander’s independent weapon station and almost 360° defensive fire from axis of primary weapon and coaxial machine gun.

5.2. GCV: First HSI/MANPRINT SSvA Report

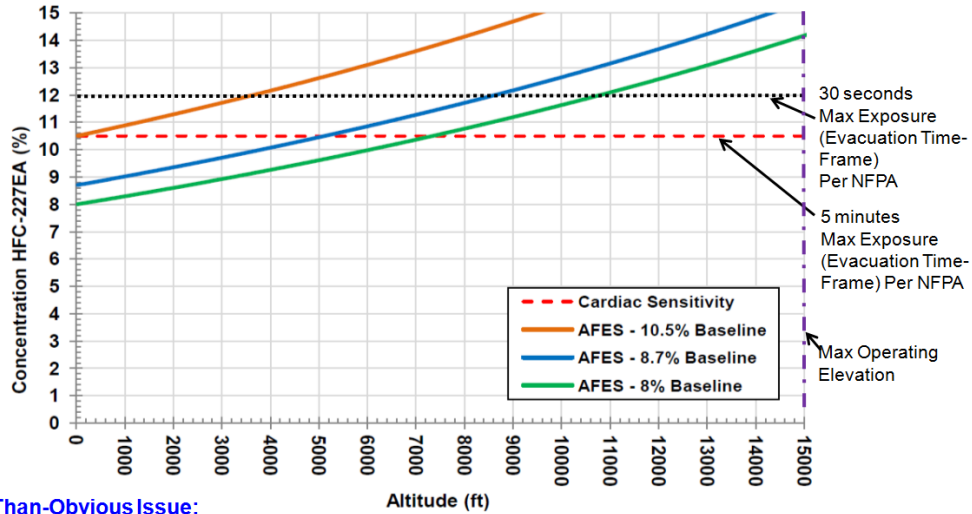
SSvA developed and submitted as a CDRL by BAE Systems in coordination with Northrop Grumman, 2013–2014. First HSI/MANPRINT SSvA report developed and submitted as a CDRL by General Dynamics Land Systems in coordination with Lockheed Martin Corporation, 2013–2014. Both company teams were introduced to SSv and taught and provided materials via PM GCV by R Zigler.

5.3 GCV: Automated Fire Extinguishing System (AFES) FM-200

- Percent concentration in interior.
- For DuPont FM-200 (HFC-227ea) fire extinguishing agent, lowest observable adverse effect level is >10.5% for cardiac sensitization.
- No observable adverse effect level is 9.0%.
- PAL issue: IV.1.f. Does the system prevent or protect the crew from toxic gases from fires?
- Platform includes an AFES that will help prevent the generation of fire and the resulting toxic gasses. AFES system will use FM-200 (1,1,1,2,3,3,3-heptafluoropropane) with small quantities of sodium bicarbonate, a scavenging agent that reduces the levels of hydrogen fluoride (HF) formed when extinguishing a Class B fire.
- FM-200 decomposes under elevated temperatures, producing HF, carbonyl fluoride, carbon monoxide, and carbon dioxide.
- Figures 13 and 14 show the exposure limits (no fire) for HFC-227ea according to the National Fire Protection Association (NFPA).

Concentration (%volume/volume)	Max Exposure Time (minutes)
Up to 10.5	5
11	1.13
11.5	0.60
12	0.49

Fig. 13 Change of AFES HFC-227ea concentrations vs. maximum exposure¹³



Less-Than-Obvious Issue:
Heavier-than-air => concentration settles
toward floor (dazed? wounded?)

The change of HFC-227EA concentrations as a function of altitude, if the AFES is designed to operate at 68°F and at sea level. Chart is still unofficial at this time.

Contributed by M. Kaufman. This figure is based on the guidance provided in Design Manual, HFC-227ea Extinguishing System, Bettati Fire Technology, Reggio Emilia, Italy, 3 August 2007.

Fig. 14 Change of AFES HFC-227ea concentrations vs. altitude¹⁴

All testing over the past several decades was performed at sea level with no consideration of the consequences resulting from changes in altitude or in big changes in temperature. The recent findings have been coordinated with PM GCV, US Army Tank Automotive Research, Development and Engineering Center (TARDEC) Fire, both GCV contractors, US Army Public Health Command (Health Hazards), and others.

A separate issue was raised to increase Army awareness of very high flame temperatures causing FM-200/HFC-227bc to decompose into potentially serious amounts of toxic gases, such as HF, carbonyl fluoride, carbon monoxide, and carbon dioxide, within an interior volume. This information was used in vehicle toxicity awareness and battery placement within vehicles. System design and system evaluation have advanced the knowledge in the field in regard to combined toxic effects from 2 separate materials that independently do not affect humans. This finding was also used in MANPRINT SSvAs and reports regarding equipment locations and fire sensors.

5.4 Ground Combat Vehicle

Inserted into the program ICD was a need for air bottles producing air/oxygen for 5 min at a 20-ft water depth. This would help calm troops whose vehicle has fallen into a canal or other body of water while overcoming spatial disorientation and then searching for hatches to open and escape through. This could also extend the time

(double or much longer) troops may have to stay within a vehicle volume when FM-200/HFC-227bc has been released. This capability was first assessed in the Air Warrior program.

5.5 Joint Air-to-Ground Missile

One of the issues identified for the JAGM was the potential for fratricide from employing a guided munition at ranges beyond line of sight (BLOS) from the firing platform or the sensing/guiding platform. The desired range far exceeded the sensor range for aviation or ground platforms. This raised the possibility of inadvertently targeting friendly or coalition forces in the general area if the missile lost lock or picked an incorrect target. The US Army Aviation Center of Excellence (USAACE) revised tactics, techniques, and procedures (TTPs) for BLOS engagements or cooperative engagements to reduce this risk. The PM made improvements to the sensor and engagement software, which allowed a “regret avoidance” mode to divert the missile from engaging an incorrect target. These changes mitigated the risk and also improved Soldier confidence in the ability to engage the correct target from long BLOS ranges or for cooperative engagements around blocking terrain. With the program being restructured, the current JAGM increment 1 is range-limited (using a Hellfire missile motor). However, the necessary decision software and TTPs are in place for extending the range in future increments.

5.6 Design Philosophy

In an unpublished 2001 paper written about contractor survivability concepts that should be incorporated in the then-new Future Combat Systems’ Manned Ground Vehicles, ARL’s R Zigler wrote the phrase “360 degree hemispheric protection” for the requirement of any armored vehicle that must close with the enemy in a village, town, or city. Before, Air-Land Battle Doctrine emphasized bypassing urban terrain, and the frontal horizontal 60° arc of a vehicle was the most protected. This phrase was adopted and used by then Army Chief of Staff General Eric Shinseki’s Future Combat Systems group, by TRADOC in its required capabilities for the Future Combat Systems’ Manned Ground Vehicles design program, and in the follow-on GCV program. The Army’s Program Executive Office (PEO) and PMs for these systems have also incorporated this phrase in their documents and briefings for the last dozen years, while the associated contractor companies have also incorporated this phrase into their documentation.

6. Who Does HSI/MANPRINT SSv Bring in for Expertise? Are HSI/MANPRINT SSv Assessors Involved in Building an ARL-Wide Cross-Directorate Community?

SSv assessors will reach out to those with the applicable expertise associated with many diverse areas to assure informed coverage for the issues and potential issues. The following is a listing of some of the organizations whose personnel provide expertise and input into a number of the SSvAs. Assessors are not only reaching across ARL directorates to provide expertise and insight, but also across the AMC's Research, Development and Engineering Centers and a number of other organizations, building working relationships and strengthening bonds of collaboration.

- PM Stryker Brigade Combat Team: Technical Management Division, Product Manager Stryker Development, Deputy Product Manager Stryker Development, Assistant Product Manager, Test and Evaluation Group, Survivability Group, Production Group, APG Field Office, Engineering Group, Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance Group
- General Dynamics Land Systems/Lockheed Martin Corp/Raytheon Corp.
- TRADOC capability manager
- ATEC/Army Evaluation Center: Stryker AST Chair; Live-Fire Test Evaluator, Non-Ballistic Evaluator, Design of Experiments, Reliability and Maintainability, Ballistics
- ATEC/Aberdeen Test Center
- Office of Under Secretary of the Army (Test and Evaluation)
- Office of Deputy Assistant Secretary Of Defense for Developmental Test and Evaluation
- Director, Operational Test and Evaluation (DOT&E), Deputy Director, Live-Fire Test & Evaluation
- Institute for Defense Analyses (supporting DOT&E)
- TARDEC
- ARL/Weapons and Materials Research Directorate (WMRD)

- ARL/HRED: human factors expertise; cognitive and physical workload analyses
- US Army Materiel Systems Analysis Activity
- Service Engineering Company
- MITRE Corporation
- Joint Project Manager for Nuclear, Biological and Chemical Contamination (JPM NBC)
- JPM NBC Contamination Avoidance
- Chemical, Biological, Radiological, and Nuclear Defense Information Analysis Center
- TARDEC Safety: related safety issues
- TARDEC Fire: coordinating on altitude effects of FM-200/HFC-227ea release on toxic effects on humans
- US Army Public Health Center: toxicological effects of R-134a refrigerant on humans; FM-200 on humans; altitude effects of FM-200/HFC-227ea release on toxic effects on humans; combined effects of FM-200 extinguishant and R-134a refrigerant; coordinate combined effects of combustion by-products of FM-200 extinguishant
- PM GCV: chemical effects CBRN; survivability in armored vehicles; coordination with contractors
- BAE Systems/Northrop Grumman Corp./Artis LLC
- Battelle Memorial Institute: ammunition compartmentation
- PM WIN-T: radiation hazard of WIN-T equipment; received report for US Army Public Health Command
- HQDA G-1 MANPRINT Directorate
- Defense Intelligence Agency/TRADOC: provide System Threat Assessment Reports that support the evaluation of the system
- Consolidated Analysis Center, Inc., White Sands Missile Range (WSMR), NM: provides early user assessment reports on systems being evaluated in support of HRED
- PM Joint Personnel Identification, Version 2

- US Army Medical Command's Institute of Public Health, APG: provides reports on health hazard assessments of the systems
- Survivability, Vulnerability, and Assessment Directorate, WSMR: provides results of electromagnetic environmental effects (E3s) testing of the systems being evaluated to include electrostatic discharge, lightning effects, EMI, electromagnetic compatibility, and high-altitude electromagnetic pulse
- ARL/SLAD Electromagnetic Vulnerability Analysis Facility: provides the results of radio frequency detection and jamming susceptibility analysis of the system under evaluation for inclusion into the SSvA report
- ARL/SLAD Electro-Optical Vulnerability Analysis Facility: provides the results of electro-optical vulnerability analysis and passive detection reports for inclusion into the SSv Assessment Report
- West Desert Test Center, Dugway, UT: provides the results of CBR paper analysis of the system undergoing evaluation for inclusion in the SSv Assessment Report
- PM THAAD
- PM Patriot PAC-3 Missile Segment Enhancement
- PM Integrated Air and Missile Defense
- PM Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System
- PM OH58F Cockpit and Sensor Upgrade
- PM Biometrics Enabling Capability, Increment 1
- Joint Attack Munition System and JAGM product offices (HSI/MANPRINT lead): program documentation, specifications, and standards
- Aviation and Missile Research, Development, and Engineering Center Safety: test data and assessment on propellant, warhead, and fuze safety
- USAACE: doctrine, TTPs, and Soldier skills and practices

7. Does HSI/MANPRINT SSv Receive Public Recognition (e.g., in the Press and Elsewhere)?

Examples of public recognition are the following:

- External and internal: the SLAD Bulletin, Volume 2, Issue 5, April 2014, has a short article about the HSI/MANPRINT SSv domain on the front page, shown in Fig. 15.¹⁵

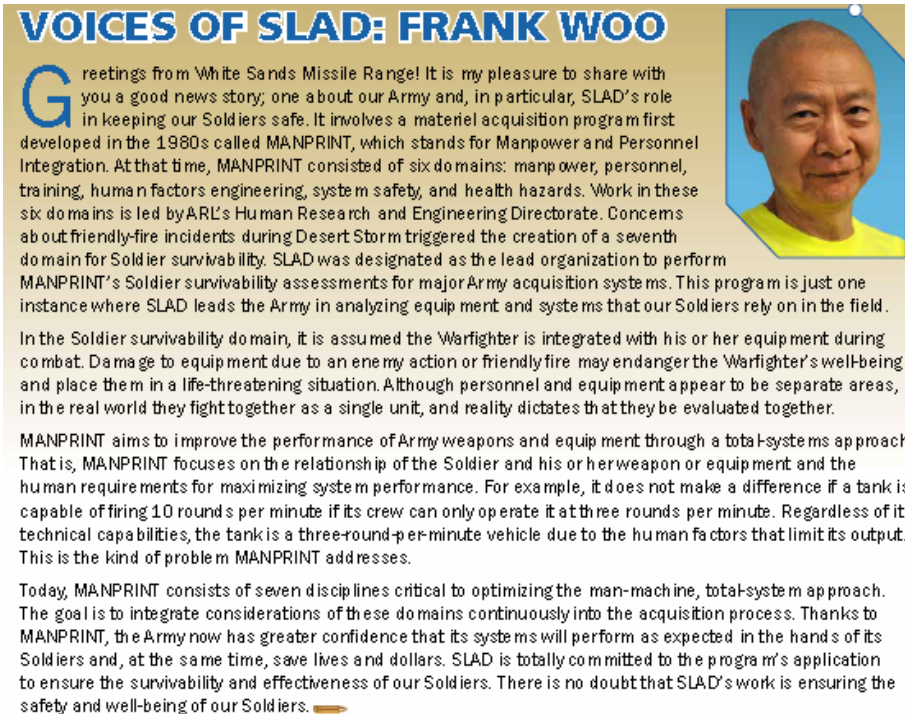


Fig. 15 Article on HSI/MANPRINT SSv by ARL's Frank Woo

- External: Contractor HSI/MANPRINT manager public statement to Preliminary Design Review audience on the value of HSI/MANPRINT assistance to their design (2013)
- External: Certificate of Appreciation to R Zigler by PM GCV (2011)
- External: Monetary award to R Zigler by PM GCV (2011)
- External: HQDA G-1; Director's Coin presented to R Zigler by HSI/MANPRINT Director Dr Michael Drillings (2011)
- External: Requested by the Army Acquisition Executive to be a member of the second PEO-I GCV Source Selection Board to perform a phase 2

- evaluation, Force Protection Group of Survivability Team (January–August 2011)
- External: Requested to be a member of PEO-I GCV Source Selection Board, Force Protection Group of Survivability Team (May–August 2010)
- External: Invitation by Clarion Defence and Security to be a special guest and speaker at their Soldier Survivability Conference, Frankfurt, Germany, 12–14 October 2010
- External: HSI/MANPRINT Practitioner of the Year Frank Woo (2004)
- External: Army Regulation 602-2 Manpower and Personnel Integration in the System Acquisition Process, Section III, paragraph 2-18.d. HSI/MANPRINT SSv becomes effective on 7 October 1994 (primary involvement by Dr Don Headley (ARL/HRED), MAJ Mitchell Howell (HQDA ODCSPER MANPRINT Directorate), Dr Robin Keesee (ARL/HRED), and R Zigler, Chair (ARL/SLAD))

8. Are HSI/MANPRINT SSv Assessors Participating on Review Panels?

Assessors are participating in a number of review panels and getting an early start on system assessments. The following are some of the panels on which HSI/MANPRINT SSv evaluators have participated:

- HSI/MANPRINT Working Groups, semi-annual with Missile Defense Agency
- HSI/MANPRINT Working Groups, quarterly and semi-annually
- GCV: Turret Systems Preliminary Design Review of General Dynamics Land Systems/Lockheed Martin turret (October 2013)
- GCV: BAE Systems Preliminary Design Review (September 2013)
- GCV: BAE Systems Periscope Preliminary Design Review (August 2013)
- GCV: BAE Systems Structures/Survivability Preliminary Design Review (June 2013)
- GCV: BAE Systems JACK Model Review at APG, June 2013; BAE's chief engineer and others, Northrop Grumman Corp., US Army Public Health Command, ARL/HRED (JACK, a registered trademark of Siemens, is a human modeling and simulation software solution used by ARL.)

- GCV: Source Selection Evaluation Board (January–August 2011)
- GCV: Source Selection Evaluation Board (May–October 2010)
- GCV: Panel to review General Dynamics Land Systems CDRL A0046 SSvA
- GCV: Panel to review General Dynamics Land Systems CDRL A0032 System MANPRINT Management Plan (SMMP) data
- GCV: Panel to review BAE Systems CDRL A0046 SSvA
- GCV: Panel to review BAE Systems CDRL A0032 SMMP data
- GCV: Panel to review General Dynamics Land Systems CDRL F.3.13 SSv mitigation plans
- GCV: Panel to review BAE Systems CDRL F.3.13 SSv mitigation plans
- GCV: Panel to review General Dynamics Land Systems CDRL A0051 Test and Evaluation Program Plan (Contractor Master Test Plan)
- GCV: Panel to review BAE Systems CDRL A0051 Test and Evaluation Program Plan (Contractor Master Test Plan)
- JAGM HSI/MANPRINT Working Group
- JAGM System Safety Working Group
- JAGM T&E IPT
- JAGM Live Fire T&E (LFTE) Working Group
- GCV: Panel to review BAE Systems CDRL A0028 Hazardous Materials Management Program (HMMP) Report
- GCV: Panel to review General Dynamics Land Systems CDRL A0028 HMMP Report¹⁶
- GCV: Panel to review BAE Systems CDRL F.3.14 CBRN Study
- GCV: Panel to review General Dynamics Land Systems CDRL F.3.14 CBRN Study
- GCV: Panel to review BAE Systems CDRL F.3.20 HSI/MANPRINT Event Report
- GCV: Panel to review General Dynamics Land Systems CDRL F.3.20 HSI/MANPRINT Event Report

- GCV: PM GCV, General Dynamics Land Systems, ARL/WMRD/SLAD Qualitative Vulnerability Assessment Meetings; face-to-face with the contractor's system engineers, armor and structure design engineers, human factors engineers, PEO and PM principals, and others representing General Dynamics Land Systems, Lockheed-Martin, and others
- GCV: PM GCV, BAE Systems, ARL/WMRD/SLAD Qualitative Vulnerability Assessment Meetings; face-to-face with contractor system engineers, armor and structure design engineers, human factors engineers, PEO and PM principals, and others representing BAE Systems, Northrop Grumman, and others
- GCV:HSI/MANPRINT SSv Working Group Meeting; PM GCV, ARL/SLAD, General Dynamics Land Systems, Lockheed-Martin, and others; review and raise issues
- GCV: HSI/MANPRINT SSv Working Group Meeting; PM GCV, ARL/SLAD, BAE Systems, Northrop Grumman, and others; review and raise issues
- Requested member of HSI/MANPRINT Cause and Effect Workshop (2010)

9. Is There Adequate Educational Outreach for HSI/MANPRINT SSv? Are There Papers on HSI/MANPRINT SSv in Conference Proceedings?

9.1 SSv Educational Outreach

Educational outreach is being provided by the US Naval Postgraduate School's (NPS's) Human Systems Integration Program, established in 2003. Class time is devoted to SSv in course OA4406 (3-1), Safety, Survivability, Health Hazards, and Habitability,¹⁷ which also ties in with their courses on DoD acquisition and systems engineering.

A second brief introductory session on SSv is provided by the Army G-1 HSI Directorate virtually or on site at the Huntsville/Redstone Arsenal (AL) and Fort Rucker (AL) locations.¹⁸ This 2.5-h Army HSI process course is conducted every other Tuesday in Huntsville.

A third and very substantial educational outreach was initiated in 2014, establishing contact with Chris Adams and Dr Robert Ball to support their development of a Ground Vehicle Survivability and Force Protection (GVS&FP) Educational

Program (EP) at NPS (email from Dr Robert Ball to author, 6 October 2014; unreferenced). A few years ago, Mr Richard Sayre, then DOT&E, funded a proposal submitted by the NPS Center for Survivability and Lethality for the multiyear development of a GVS&FP EP similar to the Aircraft Combat Survivability (ACS) EP developed at NPS beginning in 1977. (LFT&E also funds the ACS EP at NPS.) The GVS&FP EP will be at the For Official Use Only level and will eventually include the same educational products that were developed for the ACS EP: a comprehensive textbook, a graduate-level course at NPS, a short course, thesis research, and educational videos. Support was provided to Dr Ball and C Adams to assist in expanding their survivability views on ground combat systems.¹⁹

9.2 Mentor/Advise NPS Students on their HSI Master's Theses

Advice, insight, and information has been provided to NPS students when requested. Two Army majors working on theses requested assistance, which was provided. A third major requested assistance on his thesis, for which 30 MB of information plus points to consider were provided.

Example email excerpt from R Zigler to the third major (8 May 2013):

If I was doing your thesis, points I would like to consider even if I did not use them in the 4-factorial ANOVA design you spoke of:

- 1) FIRST PHASE BEGINS - Fear of sudden surprise of realizing the closed-up vehicle was going down fast
- 2) Depth of the water at various points along the route
- 3) How fast does the AAV sink?
- 4) If the vehicle rolls, will I and everyone else experience spatial disorientation? Likely yes, unless one grabs onto something to maintain orientation to the vehicle features.
- 5) Water temperature outside - the colder it is, the less time I/we have. At 28-32F, one has about 5-10 minutes before the fingers and hands stop working. After that, someone else would have to lift you up out of the water as you can no longer save yourself - there should be a nice table from the Canadian Red Cross portraying this in the materials I sent or that you may have dug up. However, when the USS Stark was hit by 2 Iraqi Exocet cruise missiles in 1987, one sailor was blown off the ship into the 85F Persian Gulf and dog-paddled and floated for about 12 hours until another frigate showed up when backtracking USS Stark's course to see if they could find any missing sailors.
- 6) When the vehicle fills with water, it will become DARK.
The deeper one goes into the depths, the greater the volume of air at sea-level is needed in the lungs to counter the water pressure outside the body. E.g. Five minutes of air at the surface equates to about thirty seconds of air at twenty feet of depth. In 2004 it was US Naval Postgraduate School's Lieutenant Commander Barton (Dr. Nita Shattuck's assistant instructor at the time) who spoke of her testing experience as a member of a 4-person group that had to go thru a periodic training of simulating a helicopter ditching, with the helicopter simulator turning over in the water. She was about 5' 3" tall, and another person was a guy of about 6' 2". Underwater, as everyone was trying to make their way out of the simulator and get to the surface, the tall guy gave a strong swim kick to go out of the simulator and upward toward the surface. Unfortunately,

his foot struck her square between the eyes and really shook her up. She recalled this incident, how her test cycle was coming up again, and the memory was filling her with dread.

- 7) Web belts and other gear can get caught on projections inside the vehicle and on the corners of the hatch(s) when trying to get through.
- 8) Realize the Survival Emergency Air II or similar breathing device has the potential to calm each Marine - knowing one has up to 5 minutes of air (Air Warrior program requirement at 20-foot depth) to figure out how to get out of the dark cold maze of desperate people and limited escape points
- 9) Closed hatches may not open until the pressure is equalized with the outside water.
- 10) Physiologically, when the body is immersed with water of 77F or lower, the body undergoes an INVOLUNTARY gasp for air to fill the lungs – whether there is only water there to breathe in or air. If the vehicle lands on its top, will I/we still be able to get out? i.e. how many hatches have been blocked? How long has it been since I took my last breath, and how long does it take to get the ramp door or the ramp itself open - first to equalize pressure and then to open?
- 11) How long does it take to get to the surface at varying depths? A diver might be able to help you with this one - don't ask here as we had 3 divers die within about a 6-week period here at APG's "Super Pond" this year.
- 12) How long will it take if one has broken one's leg or arm during all this?
- 13) Unconscious? - hopefully good fortune is really smiling on this one.
- 14) In a range of times - physiologically, how long does it take to drown?
- 15) SECOND PHASE - Once one has reached the surface, if one does, the SECOND PHASE of survival begins - how to stay alive until rescue arrives or until you can figure out how to get out of the water.
- 16) THIRD PHASE - Once one gets out of the water - if rescuers have you then you can generally let them care for you - BUT if you and/or you and others make it this far, what are you going to do to stay alive for a period of time until potential rescue??? Do you have your knife/bayonet with you? Warmth? Ability to dry off and to stay semi-dry? Etc.

Anyway, above would be my laundry list that would at least be considered if I was assessing the AAV in water going to or from shore.

9.3 Suggested Training/Exposure/Inputs

At ARL there are a number of on-the-job training opportunities that can lead to greater technical understanding and exposure to potential issues that can greatly broaden an assessor's ability to perform the SSvA task. The following list of topics and associated potential issues would be very useful to a HSI/MANPRINT SSv assessor to be either trained in or exposed to:

- Electronic warfare
- Information warfare
- Human physiology and toxicology
- Jamming of communication systems
- Optical augmentation of detection and optical cross-section measurements
- Lasers and laser protection

- Ballistics: behind-armor debris, LFTE, body armor, and ballistics protection
- CBRN, contamination survivability, and individual protective equipment
- Mechanical design of military equipment
- Acquisition process and acronyms
- Threat capabilities
- HSI/MANPRINT domains
- Human factors engineering
- ARL/SLAD services, capabilities, and products
- PM, Army Evaluation Command, or applicable acquisition experience
- Familiarity with the SSv PAL of potential survivability issues

9.4 Conference Papers

The following are examples of HSI/MANPRINT SSv papers in conference proceedings, presentations, educational outreach (serving on graduate committees, teaching/lecturing, invited talks, mentoring students) by HSI/MANPRINT SSv POC R Zigler:

- Requested presentation: “Maximizing Performance with MANPRINT & Soldier Survivability,” Department of Defense Human Factors Engineering Technical Advisory Group, APG, May 2014.
- “Maximizing the Goodness of MANPRINT & Soldier Survivability,” MANPRINT Practitioner’s Workshop, Alexandria, VA, March 2014.
- “Soldier Survivability 2012,” 2012 MANPRINT Workshop, Alexandria, VA, September 2012.
- Interviewed by Dr Nita Shattuck and Diana Kim of NPS about the MANPRINT SSv PAL, February 2011. The taped interview was used in the “Tools, Techniques, Approaches, and Methods” course Dr Shattuck was teaching/developing.
- Requested speaker, “Soldier Survivability Assessment Insights” at Tennessee Valley Human Factors Engineering Society, Huntsville, AL, 2011.
- Requested speaker and special guest on SSv by Clarion Defence and Security during their 12–14 October 2010 Survivability Conference.

- Clarion had 400–600 attendees with 40 nations represented at this event held in Frankfurt, Germany.
- Interviewed by Dr Linsey Barker and team at the University of Missouri-Columbia, “US Army Needs Assessment for Human Systems Integration,” sponsored by the Leonard Wood Institute, 2010. Request made via Dr Alan Davison of HRED.
- Requested speaker at MANPRINT Practitioners Workshop. “Soldier Survivability Assessment Insights.” Crystal City, VA, 17–18 March 2010.
- Designated member of Future Combat System’s “Systems-of-Systems” Engineering & Integration, System of Systems Design Team, as the MANPRINT SSv evaluator, 2008–2010.
- A number of presentations and papers have been presented during the 20 years of the SSv domain’s establishment and operation.

9.5 Capturing Past Expertise: Prepared for Review and Publication

ARL’s Dr RA Weiss, a physiologist, was granted full professorship to prepare and teach course OA 4406 “Environmental Issues for Safety and Occupational Health” to graduate students at NPS working on their master’s degrees in Human Systems Integration during the fall 2004 term. These lectures and instructions were recorded for continued use.

Course description: This course will provide an overview of personnel survivability, habitability, safety, health hazards, and occupational health concepts. The evaluation of new and modified military systems and equipment for safety and potential health hazards will be addressed through reviewing models, methods, and processes available to help identify and mitigate the potential harm from accidents and hostile environments. Occupational health concerns will be addressed and methods of alleviating or minimizing workplace hazards will be analyzed. Risk analysis and mitigation models also will be examined for their contribution to increased safety and operational effectiveness.

The following videotaped lectures by Dr Weiss have been transcribed, technically reviewed, and edited. Those with an asterisk (*) have been taken halfway through the ARL public release process, and the remainder are awaiting their turn:

- Lecture 1: Introduction*
- Lecture 2: Parameter Assessment List*

- Lecture 3: Contents of MANPRINT Assessment Report*
- Lecture 4: Fratricide*
- Lecture 5: Don't Get Detected/Don't Get Acquired*
- Lecture 6: Don't Get Hit or Attacked
- Lecture 7: Minimize Damage
- Lecture 9: Stress and Fatigue*
- Lecture 10: Environment/Weather*
- Lecture 11: Habitability*
- Lecture 12: Air Composition and Pressure*
- Lecture 14: Communications
- Lecture 15: Radio Frequency/Microwave/E3I
- Lecture 16: Vibration/Acoustic Noise
- Lecture 17: Acceleration/Stabilization
- Lecture 18: Acclimatization
- Lecture 19: Clothing
- Lecture 20: Navy/Coast Guard Examples
- Lecture 24: Fire Protection
- Lecture 26: System of Systems Integration
- Lecture 27: Establishing Contract and Specification Requirements
- Lecture 28: Test and Evaluation Support

9.6 Publication

Zigler RN, Weiss RA. "Personnel Survivability Methodology." In: Booher HR, editor, *Handbook of Human Systems Integration*. New York: John Wiley & Sons; 2003. ISBN 0-471-02053-2 & ISBN: 978-0-471-02053-0 (at the direction of SLAD Director Dr James Wade). Book shown in Fig. 16.

Figure 16 shows the cover of *Handbook of Human Systems Integration* by Harold B Booher.

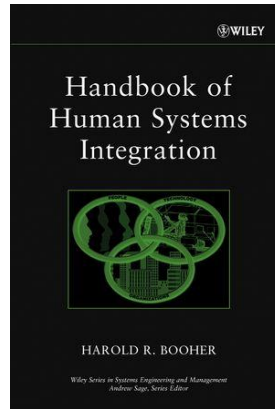


Fig. 16 *Handbook of Human Systems Integration*

Abstract: The US Army HSI/MANPRINT program established its SSv domain in 1994 to assure that the varying aspects of fratricide and survivability of its personnel would be addressed during the acquisition processes that developed its equipment. A chapter discusses the concept of Army SSv and how it is addressed in the acquisition process.

Survivability is the ability to exist and function through and after exposure to hostile situations or environments. This can apply to both personnel and equipment. With personnel survivability, the application is focused on the human while analyzing the threat and equipment as to potential effects on the human. In the military sector, survivability can be illustrated in many different ways, from living through pitched battles on land, on and under the sea, and in the air, to exploring hostile regions of the world.

The Army's HSI/MANPRINT SSv domain was established 7 October 1994 by Army Regulation AR 602-2, Manpower and Personnel Integration (MANPRINT) in the System Acquisition Process. HSI/MANPRINT is the Army program established to comply with the Office of the Secretary of Defense HSI requirements. ARL/SLAD was designated by paragraph 2-16.d. as the lead organization to perform HSI/MANPRINT SSv assessments for Army acquisition systems.

The SSv domain was established to assist materiel developers, combat developers, evaluators, and decision-makers. The 6 components of SSv assessment are:

- Reduction of fratricide
- Reduction of detectability of the Soldier
- Reduction of the probability of being attacked

- Minimization of damage incurred
- Minimization of injury incurred (those issues which may not be covered in a Health Hazards Assessment)
- Reduction of physical and mental fatigue

The primary difference between SSv and the other HSI/MANPRINT domains is that SSv addresses issues involving enemy and friendly combat weapons–induced injuries and the inherent hazards to the human under threat/combat conditions. Under normal noncombat environment operating circumstances, some related issues would be considered to also be within the realms of the human factors engineering, systems safety, and health hazards domains of HSI/MANPRINT. When potential combat weapons–induced threat exposure is included, these issues are evaluated with a combat survivability perspective.

10. Are Awards (External and Internal) Being Given to HSI/MANPRINT SSv Assessors?

No known ARL internal awards have ever been given to HSI/MANPRINT assessors for their work. Public recognition for ARL HSI/MANPRINT SSv assessors and their work is portrayed through the following examples:

- External: Contractor HSI/MANPRINT manager public statement to Preliminary Design Review audience on the value of HSI/MANPRINT assistance to their design (2013)
- External: Certificate of appreciation to R Zigler by PM GCV (2011)
- External: Monetary award to R Zigler by PM GCV (2011)
- External: HQDA G-1 HSI/MANPRINT Director’s Coin presented to R Zigler by HSI/MANPRINT Director Dr Michael Drillings (2011)
- External: Requested by the Army Acquisition Executive to be a member of the second PEO-I GCV Source Selection Board to perform a phase 2 evaluation, Force Protection Group of Survivability Team (January–August 2011)
- External: Requested member of PEO-I GCV Source Selection Board, Force Protection Group of Survivability Team (May–August 2010)
- External: HSI/MANPRINT Practitioner of the Year, Frank Woo (2004)
- External: NPS Operations Research Coin presented to R Zigler for a 2-h lecture (2004)

11. What Is Improving?

The recent trend of improvement is the increasing awareness and detection of the less-than-obvious combined effects that are generally not detected by PM staff, contractors, and other governmental agencies. Only by becoming very familiar with a design and some previously detected issues can an evaluator become more sensitive and capable in detecting these “less-than-obvious” issues.

Another trend is that a number of PM offices are recognizing the requirement for an SSvA and are contacting ARL to have this function performed. During the domain’s early years, effort on a number of levels had to be expended to increase awareness of this new HSI/MANPRINT domain. It was recognized that the customer POCs and staff members would have to be exposed to this need on a continuing basis over a period of years or decades.

12. Does HSI/MANPRINT SSv Represent an Area Where Application of ARL Strengths Is Appropriate? What Are the Available Opportunities and the Challenges Confronting MANPRINT SSv?

The HSI/MANPRINT SSvA is mandated for Army acquisition programs through the HSI requirement of DoD Instruction 5000.2, 12 May 2003, and through Army Regulation 602-2 Human Systems Integration in the System Acquisition Process, 27 January 2015.¹ AR 602-2 directly names ARL as responsible for ACATs I, II, and III SSv issue generation and assessment responsibility. ARL has established itself as having expertise in the survivability field through its long record of working electronic warfare, ballistic, cybersecurity, and CBRN vulnerability and susceptibility analyses for platforms used in the battlefield environments. ARL’s technical reputation in survivability, vulnerability, and lethality is known in PM offices and in LFTE, test, and analysis communities. ARL speakers on HSI/MANPRINT SSv are recognized and often requested for HSI/MANPRINT, HSI, and other related events. A number of requests for SSv reports and often other business opportunities come to the SSv POC because of his visibility within the HSI/MANPRINT community.

12.1 Strategy

Both an opportunity and a challenge, the strategy for marketing HSI/MANPRINT SSv is to educate PMs and prime contractors about this program requirement and

to focus their attention on ARL to fulfill this requirement for them. Customer focus in a PM office and in a contractor team would logically be placed on whoever is designated to handle HSI/MANPRINT as a whole or whomever is designated to be their survivability lead. The leads have been observed at times to be the chief of logistics, a designated HSI/MANPRINT lead, a systems engineering chief, or a survivability leader.

12.2 Method of Sales

The primary method of sales for ARL technical analyses, investigations, and HSI/MANPRINT SSvAs to PM and contractor customers is to become involved in a program as early as possible and meet with them face to face during program meetings and private meetings.

12.3 Advertising and Promotion

A great deal of advertising and promotion structure exists for the HSI/MANPRINT SSv domain. ARL's field element personnel (HRED) and system leaders (SLAD) are generally ARL's leading-edge personnel in contacting PMs, contractors, and TRADOC personnel about emerging programs, often assisting in construction of JCIDS capabilities documents, analysis of alternatives studies, and participating on source selection boards.

The HQDA G-1 HSI/MANPRINT Directorate makes an appearance in almost all Army System Acquisition Review Council (ASARC) meetings, usually representing the G-1 (a lieutenant general). This promotes the importance of HSI/MANPRINT to the PMs and PEOs. The HQDA HSI/MANPRINT Directorate maintains contact with the various PMs, especially in the time frame leading up to an ASARC meeting. This is accomplished by providing the overall HSI/MANPRINT assessment report and ratings, meetings, and telephone calls. The HQDA G-1 HSI/MANPRINT Directorate sponsors its own HSI/MANPRINT Workshop every 18 months, an event expressly mandated by AR 602-2, and supports the bi-yearly American Society of Naval Engineers' Human Systems Integration Symposium, while in the past sponsoring HSI/MANPRINT booths at conferences and in the Pentagon 3–4 times per year. It also provides a website at: <http://www.armyg1.army.mil/HSI/>. The HQDA G-1 HSI/MANPRINT Directorate also emails its HSI/MANPRINT newsletter to HSI and HSI/MANPRINT practitioners in the military departments and in DoD-related commercial industry, and posts the newsletter on its internet site. This newsletter also lists on the second page the HSI/MANPRINT domain POCs and their contact information.

ARL provides a POC for the Army's HSI/MANPRINT SSv program, responding to governmental organization and contractor queries and requests. In this role, ARL has been invited to speak on the SSv program at the HSI/MANPRINT Workshops, NPS, US Military Academy, DoD Human Factors Engineering Technical Advisory Group conferences, the American Society of Naval Engineers' Human Systems Integration Symposium at Motorola University, and to the US Army Logistics University's HSI/MANPRINT action officer's courses.

Previous exposure of PM and support personnel to HSI/MANPRINT SSv via education or familiarization opportunities will often plant early thoughts and considerations for inclusion of SSv and HSI/MANPRINT activities into programs. ARL's SSv representative maintains contact with HSI/MANPRINT instructors Dr Nita Shattuck of HSI/NPS and Mr L Taylor Jones, HSI/MANPRINT acquisition liaison of the HQDA G-1 at Huntsville, AL. Unclassified SSv-related materials are often furnished to them for information and as examples for potential use in their instruction duties. In the past there was a lot of coordination with Mr J Pat Wilson, Chair of the Legal and Contracting Committee and longtime HSI/MANPRINT instructor at the US Army Logistics University at Fort Lee, VA., but TRADOC has recently declined this HSI/MANPRINT education role due to decreased funding.

13. Biographies of Key Technical Leaders for MANPRINT SSv Assessments. Are the Qualifications of the MANPRINT SSv Evaluators Compatible with the Assessment Challenge?

Mr Matthew Kaufman is an engineer with 39 years of experience. From computer programming, production engineering, US Army program management, and HSI in survivability/vulnerability engineering and analyses, he has broad experience in solving engineering problems with complex stochastic and probabilistic modeling and simulations. A former US adviser to the North Atlantic Treaty Organization Working Group on NBC, he remains a special adviser to DoD and Department of Homeland Security. He has authored numerous government reports on survivability, but his most meaningful contributions have been his personal efforts to educate technical personnel and future subject matter experts through technical consultation, his copyrighted software suites, C-HAZMAT (which includes the world's largest and most complete chemical-materials database for personnel clothing and groundwater contamination and transport phenomena) and EVERYMAN (which includes the 2 digital progenitors, named Jean and Jerry, powered by 60,000 individual anthropometric and kinematic datasets), and the following textbooks:

- *Fundamentals of Contamination by Chemical Hazardous Materials (C-HAZMAT)*, Oakman, AL: H-Bar Enterprises, Inc.; 2001, 352 pages.
- *Soldier Survivability, Volume I: Fratricide and Amicicide*; 2006, self-published, 544 pages.
- *Soldier Survivability, Volume II: Sensitivity and Specificity of Ballistic Targets for Survivability and Vulnerability Analyses*; 2008, self-published, 391 pages.
- *Soldier Survivability, Volume II - Sensitivity and Specificity of Ballistic Targets for Survivability and Vulnerability Analyses*; 2nd edition; 2011, self-published, 478 pages.

Kaufman holds several registered copyrights, including the Board (7-ply) American Army Male Ballistic Mannequin and the Kaufman Uncertainty Principle for Geometric Modeling (which defines the limit of the representative heuristic in all analyses and engineering that employ geometric modeling), both of which offer methodology solutions for susceptibility and have contributed to the paradigm shift to probabilism throughout engineering, science, and analyses. He introduced the ballistics lethality/vulnerability analyses community to Bayesian probability statistics, and generated the first Bayesian statistical analyses of 4 common “Soldier” plywood targets, demonstrating and documenting the lethality mindset and biases in their theories and the flaws in their oft-employed representative heuristic (i.e., component-level target descriptions and analyses).

He is a lifetime founding member of the International Ballistics Society and a sponsor for the 2010 and 2011 Responsible Officer/Team Chief Conferences (Balad, Iraq); these conferences focused on Theater Property Book operations and responsibilities, particularly in regards to the retrograde from Iraq.

Mr Donald P Walker has a Bachelor of Science degree from the US Military Academy at West Point, NY; a master’s in Electrical Engineering from New Mexico State University, Las Cruces, NM; and a master’s in Strategic Studies degree from the US Army War College at Carlisle Barracks, PA. He has 29 years of experience serving as a Department of the Army civilian at ARL/SLAD where he has been involved with analyzing Army systems’ vulnerabilities and susceptibilities to audio, electro-optical, electromagnetic, infrared, laser, radio frequency, visual, and passive detection threats. He has conducted more than 10 HSI/MANPRINT SSvAs on Army systems ranging from complex systems, including the Armed Reconnaissance Helicopter and Improved Cargo Helicopter

to relatively simple systems like the ENVG, since HSI/MANPRINT SSv's establishment as a domain of HSI/MANPRINT in 1994. Mr Walker has also evaluated many Army systems for compliance with the Army's E3 requirements. In addition to his technical expertise, Mr Walker served 7 years on Army active duty and 23 years in the National Guard and Reserves. He is a graduate of the Field Artillery Officer's Cannon Basic Course, Lance Missile Course, NBC Course, Advanced Air Defense Officers Course, Command and General Staff College, and the US Army War College.

Ronald A Weiss, Ph.D., spent most of his career helping people to live and work in both natural and hostile environments from undersea to outer space while working at ARL/SLAD. As a physiologist/bioengineer, he completed SSvAs of the Air Warrior, Future Combat System, and the Joint Modular Lighterage System. Dr Weiss developed and taught the first Personnel Survivability, Safety, and Occupational Health course as an adjunct full professor in the HSI master's degree curriculum for all services at NPS during fall 2004. From June 1967 to September 1981, as Manager of Aerospace Medicine, McDonnell-Douglas Astronautics, Dr Weiss was responsible for all life science and safety aspects on the Skylab program design and operation. His research on pharmaceutical manufacturing in space was cited in the management journal *Pharmaceutical Executive*, Vol. 1, 1981. In both his first and third State of the Union messages, President Ronald Reagan mentioned Skylab as an important thrust for helping mankind to produce new drugs in quantities not technically feasible on Earth. Weiss made an important contribution while participating on a NASA team of experts to quickly develop a CO₂-scrubber work-around solution when Apollo 13 experienced its oxygen tank explosion on its mission to the moon. He worked on Sealab, Skylab, and other spacecraft, fighter aircraft such as the F-15 Eagle and the AV-8B Harrier II, and both military and civilian first-responder CBRN respirators. He earned a Ph.D. in Human Environmental Physiology from Saint Louis University Medical School and a second in Human Physiology from Columbia University. (Deceased, 2007)

Mr Frank Woo is the HSI/MANPRINT SSv Technical Subject Matter Expert for ARL/SLAD at WSMR in New Mexico. He is responsible for HSI/MANPRINT SSvAs, guidance, and policy in support of major DoD ACAT I and II programs. He has published many HSI/MANPRINT SSvA reports for PMs in the air and missile defense, ground, and aviation arenas. He has been a HSI/MANPRINT practitioner since 1994, when the seventh HSI/MANPRINT SSv domain was implemented. He received a major achievement award in 2004 from the HSI/MANPRINT Directorate as the HSI/MANPRINT Practitioner of the Year for his contributions in technology, research, and development.

Prior to joining ARL in 1985, he led research in lasers at the High Energy Laser Energy Program at WSMR. Other technical areas of expertise included acoustics, telemetry, and radar.

Mr Woo holds a Bachelor of Science degree in Physics and a master's in Bio-Engineering processes from the University of Texas at El Paso.

Mr Richard “Rich” Zigler is a general engineer with 43 years of engineering experience in mechanical design and acquisition, 32 of which were as a Department of the Army civilian focusing on combat survivability/vulnerability engineering and analyses of armored vehicles, other platforms, and Soldiers. He was one of 9 members of the 1991–1992 8-organization Process Action Team that formed ARL/SLAD and has been working in SLAD since 1993. He was chair of the committees that established the US Army's HSI/MANPRINT SSv domain and created its PAL for survivability issues during 1993–1994. Mr Zigler has been the Army's POC for the HSI/MANPRINT SSv domain since its establishment by AR 602-2 in 1994. He has worked in SLAD as a mission area coordinator for Ground Systems and for Soldier Systems, a system leader for Land Warrior program, an integrated assessment team leader for Soldier Systems (same position as a present-day mission area manager but with greater authority), and as SLAD Marketing Chair during 1998–2000. Currently assessing the 5 vehicle designs of the Armored Multi-Purpose Vehicle, he has assessed a number of complex acquisition systems ranging from Land Warrior and Future Combat System (9 manned vehicles, 4 unmanned aerial vehicles, 2 unmanned ground vehicles, and ground sensors), to the GCV's 2 competition-sensitive Infantry Fighting Vehicle designs. Prior to joining SLAD, Mr Zigler served in a number of important leadership positions as 1) Chief of ARL's US Army Survivability Management Office's Combat Systems Division, 2) Chief of AMC's Technical Analysis Branch, 3) Chief of AMC's Armor/Anti-Armor Branch supporting development of the Chief of Staff of Army's Armor/Anti-Armor Modernization Plan, 4) AMC's Weapon Systems Staff Manager for Tanks and Armored Vehicles (Abrams M1, IPM1, and M1A1 tanks; M60A3 Patton tank; M2 and M3 Bradley Infantry Fighting Vehicles; M113 FOV; M551 Sheridan tank; M88 Hercules Recovery Vehicle; Fox NBC vehicle; Armored FOV program; and Armored Gun System), 5) chief of PM Abrams Production/Facilities Support Division at the Lima Army Tank Plant (LATP; renamed Joint Systems Manufacturing Center), 6) PM ABRAMS contracting officer's technical representative for both the production and the facilities contracts for the Abrams Main Battle Tank at LATP (1.6 million square feet of manufacturing space; 369 acres; 4,000 employees of General Dynamics Land Systems; government-owned contractor-operated facility), and 7) manager of the Allied Moulded Products, Inc., Engineering Department (product design, mold

design, metal stamping design, assembly equipment design, time study, materials laboratory, Underwriters Laboratory product compliance, Factory Mutual Insurance product fire-wall testing, and quality assurance of incoming parts). Mr Zigler earned a master's in Business Administration from Saint Francis College (1982) and a Bachelor of Science degree in Aeronautical Engineering from Tri-State College (1972). He is a 1992 graduate of the US Army War College and a 1993 graduate of the 20-week Defense Systems Management College's Program Management Course. As one of the 200 original general-officer-level, panel-selected Science and Technology members (from 600+ applicants) of the Army Acquisition Corps in March 1992, he is a Certified Acquisition Professional at Level 3 in 3 functional specialties: 1) Program Management; 2) Systems Planning, Research, Development and Engineering–Systems Engineering; and 3) Production, Quality, and Manufacturing. In addition, he is a Certified Acquisition Professional at Level 2 in Systems Planning, Research, Development and Engineering–Program Systems Engineer. In 1990, Mr Zigler received the Department of the Army's Superior Civilian Service Award from AMC's MG Joe W Rigby.

14. References and Notes

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2. Zigler R. Maximizing the goodness of MANPRINT and Soldier survivability. Presentation to: G-1 MANPRINT Workshop, 2014 Mar 18–19.
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4. Human-system integration in Air Force weapon systems development and acquisition. Briefing to: Air Force Scientific Advisory Board. Final report dated 2004 Aug 10.
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6. Headquarters Department of the Army. US Army FY09 human systems integration plan. Proposed annex to the OSD HSI Management Plan, Ver. 1.0. Submitted by G-1 MANPRINT Directorate, 2009 Mar.
7. Since Fig. 6 was made in 2009, ATEC was moved to APG, and the Center for Health Promotion and Preventive Medicine performing health hazard assessments was renamed as the Army Public Health Center.
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14. Zigler R. Maximizing the goodness of MANPRINT and Soldier survivability. Briefing at 2014 MANPRINT Workshop, 2014 Mar 19.
15. SLAD Bulletin. 2014 April;2(5).
16. A number of IPT meetings were not listed, such as PM coordination meetings separately addressing programmatic efforts in a given competing contractor's design and program, structures/armor IPT, crew and squad IPT, structures and survivability IPT, lethality IPT, auxiliary IPT, or E3 Working Group. Additional meetings not listed were the many program panels and associated meetings and reviews for the years 1995–2010.
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18. Course POC: Taylor Jones. [accessed 2015 Apr 20]. <http://www.armyg1.army.mil/HSI/Training.html>.
19. Ball R. [accessed 2015 Apr 20]. <http://www.armyg1.army.mil/HSI/Training.html>. Course POC: Taylor J; lauris.t.jones2.civ@mail.mil; 256-382-4747, ext. 103; email of 2014 Oct 6 with R Ball (reball@mac.com).

Ball RE. Distinguished professor, emeritus, Department of Aeronautics and Astronautics, Department of Mechanical and Aerospace Engineering, NPS, Monterey, CA.

Intended future textbook title: The Fundamentals of Ground Vehicle Survivability and Force Protection. The essential fundamentals will appear in the body of the textbook and consist of 1) military ground vehicle capabilities, 2) vehicle survivability and occupant protection definitions and terminology, concepts, and measures, 3) the threats and their effects on a vehicle and its

occupants, 4) the survivability and protection capability measures and assessment methodology plus the technology for the design of a ground vehicle for enhanced survivability and occupant protection, 5) analyses for comparing alternate vehicle designs, and 6) the process for vehicle survivability and occupant protection test and evaluation.

The supplemental fundamentals will appear in the appendixes and consist of 1) historical, physical, and functional descriptions of several of the current US Army and Marine ground vehicles; 2) the Joint Improvised Explosive Device Defeat Organization, high-mobility multipurpose wheeled vehicle (HMWWV), mine-resistant armor-protected vehicle, and Future Combat System programs; 3) ground vehicle anatomy; 4) probability theory; 5) electromagnetic radiation; 6) a special appendix devoted to armor; 7) DoD, Army, and Marine organizations that can influence vehicle survivability and occupant protection; 8) modeling and simulation; 9) DoD acquisition and integration processes; 10) battle damage recovery and repair, GVS&FP Technology and Concept Vehicle Programs, and NBC and directed-energy survivability and protection (if covered).

The textbook of GVS&FP fundamentals will be written for both the novice in ground vehicle survivability and occupant protection (S&P) as well as those with experience in one or more aspects of S&P. It covers the evolution of ground vehicle S&P, starting with the development of the Abrams Main Battle Tank, Bradley Infantry Fighting Vehicle, and the HMWWV in the early 1980s, and progressing to the current GCV (cancelled), AMPV, JLTV, and the Marine Amphibious Combat Vehicle. Possible students include US military and civilian personnel who have been assigned to positions that involve one or more aspects of ground vehicle survivability and occupant protection within DoD and military service research, development, engineering, materiel, and operational organizations and the US military ground vehicle industry. The intent is for students to understand how to analyze, assess, design, integrate, compare, specify, and test and evaluate a ground vehicle's survivability and its capability to protect its occupants in both major combat and low-intensity asymmetric hostile environments.

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**Appendix A. Human Systems Integration (HSI)/Manpower and
Personnel Integration (MANPRINT) Soldier Survivability
Poster and Read-Ahead Sheet for National Research Council
(NRC) Technical Advisory Board (TAB) Review, 8 July 2014**

This appendix appears in its original form, without editorial change.

Soldier Performance & HSI:
MANPRINT Soldier Survivability (SSv)

Richard Zigler, ARL-SLAD, U.S. Army MANPRINT SSv POC
ARL MANPRINT SSv Evaluators (of both ARL-HRED & ARL-SLAD)



Issue: When systems are rapidly designed and developed, the integration is not seamless and the human often suffers.

Objective: Reduce fratricide, detectability, likelihood of attack, vehicle damage, likelihood and severity of injury, and fatigue (physical and mental).

MANPRINT SSv Focus: Early identification of less-than-obvious issues & their resolution

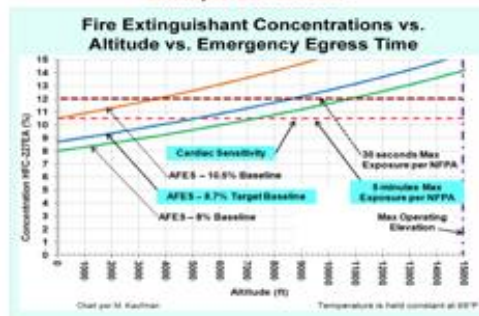
Example: "What to assess?"

- Evolving platform designs
- Ballistic design & testing
- Personnel placement
- Personnel survivability
- Threats – different types
- Survivability concepts
- Armaments & ammo
- Ammo compartment
- Mobility subsystem
- Mission sustainment
- Chemical, biological, radiation, & nuclear



- Electromagnetic environmental effects (E3)
- Human Factors Engineering
- Emergency egress (land & water)
- Countermeasures – missiles? radars? sensors? flight envelopes? propellants?
- Automatic fire extinguishing system (AFES)
- Situational awareness
- Physiology & toxicology
- Mobility subsystem
- Soldier equipment & stowage plan

Example Successes:




Combined Effects – Battery & Fire Extinguishant




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Fig. A-1 HSI/MANPRINT SSv assessment poster

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Enhancing HSI to Optimize Soldier Survivability



Soldier Performance & HSI:
MANPRINT Soldier Survivability (SSv)

Richard Zigler, ARL, U.S. Army MANPRINT SSv POC
ARL MANPRINT SSv Evaluators (of both ARL-HRED & ARL-SLAD)

Abstract

HSI/MANPRINT Soldier Survivability assessment and analysis views man-machine interaction as a whole when in combat, with the ultimate focus on the survival of the Soldier. AR 602-2 describes "Soldier Survivability" (SSv) as the characteristics of a system that include fratricide, detectability, likelihood of attack, vehicle damage, likelihood and severity of injury, and fatigue (physical and mental). Familiarity with conventional ballistics, chemical-biological-radiation-nuclear, contamination survivability, electronic warfare, information operations, information warfare, atmospheric and obscurants, directed-energy weapons, electronic countermeasures, physiology and personnel vulnerability can all be utilized at various times to reduce negative results during combat. This poster will endeavor to show several differing survivability issues and actual successes in reducing danger to the Soldier.

Objective: How can we reduce fratricide, detectability, likelihood of attack, vehicle damage, likelihood and severity of injury, and fatigue (physical and mental)?

Challenges :

- Detection of less-than-obvious issues that could affect the platform and/or personnel during combat
- Concurrently analyze rapidly-changing complex military equipment designs versus required capabilities to detect potential vulnerabilities against myriad threat capabilities in a combat environment
- Be very timely in detecting and raising issues

Approach :

- Apply experience and familiarity with system engineering, ballistics, electronic warfare, DEW, CBRN, physiology, and human factors
- Apply familiarity with threat capabilities
- Analyze emerging designs and testing for vulnerabilities and susceptibilities
- Generate, coordinate, & assist in the resolution of SSv issues

ARL Contribution :

- As requested by U.S. Army Chief-of-Staff, HQDA MANPRINT Directorate and ARL created MANPRINT Soldier Survivability Domain
- Assigned to ARL by AR 602-2, effective date 7 October 1994
- Creation of SSv Parameter Assessment List of ~200 survivability issues meant to cover all platforms and items – said to be first of its kind in the Army
- ARL complementary work occurring in HRED, SLAD, VTD, WMRD

Collaborations :

- DoD test organizations, Defense Intelligence Agency, PEO's, PM's, DoD contractors, Army Test & Evaluation Command, AMC Major Subordinate Commands, Training & Doctrine Command, Public Health Command, other DoD agencies, etc.
- U.S. Army MANPRINT SSv Domain POC: richard.n.zigler.civ@mail.mil

Impact :

- Detection, identification, and reduction or elimination of less-than-obvious vulnerabilities and susceptibilities in equipment designs
- Benefits to the Soldier resulting from this work: 1) improved ability to complete a mission; 2) improved Soldier & equipment survivability on the battlefield

Results :

- Many significant design changes & results
- Claim made at a major program Preliminary Design Review that "MANPRINT really IMPROVED our design!"
- Ch.16 – "Personnel Survivability Methodology" by R. Zigler & Dr. R. Weiss, of *Handbook of Human Systems Integration*, Edited by Dr. Harold R. Booher, printed by John Wiley & Sons, Inc., NY (2003)

Path Forward: Improve and increase potential-customer familiarity with this DoD 5000.2 Human Systems Integration mandated AR 602-2 program that is focused on increasing the survivability of the Soldier and his equipment in combat environments

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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Fig. A-2 Read-ahead/hand-out sheet to accompany poster sent ahead to NRC TAB panelists for their preparation (sent ahead but also made available for poster session of 8 July)

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**Appendix B. Excerpted Army Regulation 602-2 and Army
Regulation 70-75 Language that Applies to US Army
Research Laboratory Manpower and Personnel Integration
(MANPRINT) Soldier Survivability**

This appendix appears in its original form, without editorial change.

I. MANPRINT Soldier Survivability - Applicable Portions of Army Regulation 602-2 Manpower and Personnel Integration (MANPRINT) in the System Acquisition Process, dated 31 January 2014

Chapter 1 Introduction, 1–5. The Manpower and Personnel Integration Program

b. It is imperative that a total MANPRINT effort begins as early as possible in system acquisition and that user feedback is used to maximize the influence on system design. MANPRINT integrates and facilitates trade-offs among seven domains, listed below, but does not replace individual domain activities, responsibilities, or reporting channels. MANPRINT domains may be described as follows (see glossary):

(7) *Soldier survivability*. The characteristics of a system that reduce fratricide, as well as reduce detectability of the Soldier, prevent attack if detected, prevent damage if attacked, minimize medical injury if wounded or otherwise injured, and minimize physical and mental fatigue.

Chapter 2 Responsibilities, Section I Headquarters, Department of the Army Elements

2–5. Deputy Chief of Staff, G–1

The DCS, G–1 will—

- a. Exercise primary Department of the Army (DA) staff responsibility for the MANPRINT Program.
- f. Prior to the convening of a key in-process review (IPR) or MDR, issue a MANPRINT assessment for the MDA (Milestone Decision Authority) with copies to the PEO and/or PM. This final MANPRINT assessment will identify the critical issues requiring resolution prior to a recommendation being made for the system to proceed to the next acquisition phase.
- m. Review the application of MANPRINT in Army models, simulations, and analyses.

Chapter 2 Responsibilities, Section III Army Acquisition Executive, Program Executive Officer, and Program, Project, Product and/or Manager

2-19. Army Acquisition Executive

The AAE will include MANPRINT, as appropriate, in directives and policy statements concerning system acquisition.

2-20. Program executive officer
PEOs will-

- a. Include in PM charters the responsibility for funding and executing the MANPRINT Program.
- b. Monitor PM and contractor execution of MANPRINT Program requirements.
- c. Rate assigned PM execution of MANPRINT responsibilities and consider rating in PM performance appraisals and efficiency reports.
- d. Ensure PMs obtain MANPRINT domain assessments in support of milestone decision reviews and major system upgrades in accordance with this policy and other regulatory guidance.

2-21. Program, project, and/or product managers
PMs will-

- a. Implement a proactive MANPRINT Program for all systems managed.
- b. Exercise managerial control over the MANPRINT effort. Require a SMMP as the official management and tracking mechanism.
- c. Determine funding and resourcing requirements for effective MANPRINT Program planning, execution, and test events.
- d. Provide resources and proper funding for effective MANPRINT Program planning, execution, and test events.
- e. Use the field element designated by U.S. Army Research Laboratory Human Research and Engineering Directorate as the focal point to coordinate the MANPRINT Program and the efforts of the other MANPRINT domains.
- f. Apply MANPRINT methodologies to hardware and software development and modification, and acquisition programs.
- g. Compare MANPRINT performance parameters, objectives, and thresholds from the ICD to the RFP to the TEMP (across the system life cycle), to verify that each has been addressed as intended.
- h. Include MANPRINT considerations as an explicit part of the source selection planning and implementation processes. Emphasize use of measurable MANPRINT criteria with respect to requirements from relevant capabilities documents.
- i. Include all required and appropriate MANPRINT requirements and opportunities in the best value trade-off analyses associated with source selection as determined by the AAE.

- (1) Include MANPRINT requirements in solicitation packages in sufficient detail to permit a determination of effort required by Government and industry.
- (2) Incorporate MANPRINT provisions (planning, accomplishment, progress tracking, and documentation of required efforts) in system contracts and specifications.
- j. When appropriate, charter MANPRINT WIPTs or ensure MANPRINT is represented on another appropriate IPT (for example, Supportability IPT).
- k. Charter contractor and Government MANPRINT working groups to guide, coordinate, oversee, and assess progress of the system's MANPRINT Program.
- l. Identify and resolve, or provide a mitigation strategy for, critical and major MANPRINT risks throughout the acquisition process.
- m. Coordinate with DCS, G-1 and the U.S. Army Research Laboratory Human Research and Engineering Directorate, the resolution of MANPRINT risks, issues, hazards, and concerns during the acquisition program life cycle.
- n. Initiate requests for the conduct and preparation of MANPRINT assessment and domain assessments and provide results to DCS, G-1, the PM, and the AAE. Initiate requests not later than 120 days prior to a milestone decision or full-rate production (FRP) decision.
- o. Provide MANPRINT training for the team that is implementing the PM's MANPRINT Program, plans, and execution.

Chapter 2 Responsibilities, Para. 2–12. Manpower and Personnel Integration practitioner

A MANPRINT practitioner will—

- a. Conduct a proactive MANPRINT Program for all systems assigned.
- b. Support the assessment of domain-specific and cross-domain MANPRINT issues using methods that support the evaluation of the impact of MANPRINT considerations on total system ownership and/or life cycle costs, Soldier safety and survivability, and the integrated Soldier-system performance.
- c. Support the inclusion of all required and appropriate MANPRINT requirements and opportunities in the best value trade-off analyses associated with source selection.
- d. Conduct technical and programmatic tasks necessary to resolve MANPRINT issues and concerns to the greatest extent possible before each MDR (milestone decision review).
- e. Apply MANPRINT methodologies to hardware and software development, modification, and acquisition programs.
- f. Maintain a MANPRINT issues log in order to resolve MANPRINT issues and concerns during the acquisition program life cycle.

- g. Support the identification of MANPRINT-related program dependencies on other systems.
- h. Lead MANPRINT working groups. In cases where a MANPRINT working group is not necessary, represent MANPRINT on another appropriate IPT (integrated product team).
- i. Crosswalk MANPRINT performance parameters, objectives, and thresholds from the capabilities documents to the RFP (request for proposal) and TEMP (Test and Evaluation Master Plan).
- j. Develop funding and resourcing requirements for effective MANPRINT Program implementation, testing, and maintenance.

Chapter 3 Manpower and Personnel Integration in the Systems Acquisition Process, Para. 3–6. Manpower and Personnel Integration in other systems

- a. Joint programs.* MANPRINT equivalent for DOD and Joint Systems is HSI. For Joint programs that require Army personnel (as operators, maintainers, or supporters), MANPRINT and/or HSI policies apply. MANPRINT and/or HSI requirements will be embedded in the ICD, CDD, CPD, RFP, SOW, AoA, SEP, System Training Plan, SMMP, and TEMP, particularly the critical operational issues and criteria.
- b. Capabilities development for rapid transition process.* The Army often accelerates procurement programs for urgent needs, often identified through TRADOC warfighting experiments as compelling successes (see AR 71–9). MANPRINT practices and policies will be made an integral part of these programs by the PM or acquisition authority.

II. Army Regulation 70-75 Survivability of Army Personnel and Materiel, dated 2 May 2005

The below Army Regulation 70-75 language was referenced in AR 602-2, and vice-versa, with the cross-referencing accomplished in 1993 by G-1 MANPRINT Directorate’s Major Mitchell Howell prior to staffing of AR 602-2 to establish the Domain of MANPRINT Soldier Survivability. This has been maintained since that time.

Chapter 1 Introduction, 1–6. Policy

- c.* The System Manpower and Personnel Integration Management Plan (SMMP) will identify and track the resolution of Soldier survivability concerns throughout the acquisition process.
- e.* Analyses of survivability against each threat, to include trade-off analysis, are done in the context of all threats and balanced across all survivability disciplines to maintain overall mission performance. Fratricide due to the collateral effects of friendly systems is considered a vulnerability. Failure to control fratricide is a Soldier survivability issue and will be managed according to System Manpower and Personnel

Integration (MANPRINT) Management Plan procedures, as described in AR 602-2.

f. Survivability features of system and Soldier survivability must be designed to be maintainable throughout the life cycle.

Chapter 2 Responsibilities, 2-3. Deputy Chief of Staff, G-1

The Deputy Chief of Staff, G-1 (DCS, G-1) will—

a. Coordinate survivability aspects of the Army Soldier-Oriented Research and Development (SORD) program and other soldier survivability matters, as appropriate.

b. Develop policy and provide guidance for the assessment of Soldier survivability as a domain of MANPRINT.

Chapter 2 Responsibilities, Section II Commanders of Major Army Commands, 2-16. Commanding General, U.S. Army Research, Development and Engineering

The Commanding General, U.S. Army Research, Development and Engineering (CG, RDECOM) will—

e. Address Soldier survivability issues by performing G-1 MANPRINT domain assessments and by working with the program manager, HQDA, G-1, and USATEC communities.

Chapter 3 Procedures, 3-2. Survivability in the requirements process

Materiel survivability is addressed in the ICD in terms of the threat to be countered, the operational threat environment, and an assessment that the item is or is not mission critical/mission essential. Soldier survivability is the integration of the survivability of the individual soldier and how the system affects the Soldier's survivability.

Chapter 4 Survivability Considerations, 4-3. System of systems survivability

The traditional definition of survivability is the capability of a system and crew to avoid or withstand a man-made hostile environment without suffering an abortive impairment of their ability to accomplish their designated missions. This definition is inadequate to describe the survivability of systems of systems (SoS). SoS, for the purpose of this document, is a collection of systems (with their associated platforms) deployed in a collaborative aspect. SoS survivability is more accurately defined at the following four levels:

d. Personnel survivability— the integration of the survivability of the individual Soldier and the system affects the Soldier's survivability (in situations where individual Soldiers continue to be the focus of a close fight, and as crewmembers of manned weapons systems).

Preparing Activity

(U) This document was prepared by the US Army Research Laboratory's Survivability/Lethality Analysis Directorate, Aberdeen Proving Ground, MD, 21005-5068. Point of contact for this action is Richard N Zigler: (410) 278-8625 or DSN: 298-8625; richard.n.zigler.civ@mail.mil.

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List of Symbols, Abbreviations, and Acronyms

ACAT	acquisition category
ACS	Aircraft Combat Survivability
AFES	automatic fire extinguishing system
AMC	US Army Material Command
AMPV	Armored Multi-Purpose Vehicle
APG	Aberdeen Proving Ground
AR	Army Regulation
ARL	US Army Research Laboratory
ASARC	Army System Acquisition Review Council
ASPEC	acquisition specification
AST	ATEC System Team
ATEC	US Army Test & Evaluation Command
BLOS	beyond line of sight
CBR	chemical, biological, and radiological
CDRL	Contract Data Requirements List
CG	commanding general
CNO	computer network operation
DCSPER	Deputy Chief of Staff for Personnel
DoD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
E3	electromagnetic environmental effect
EMI	electromagnetic interference
ENVG	Enhanced Night Vision Goggle
EP	education program
FRP	full-rate production

FOV	Family of Vehicles
FWS-I	Family of Weapon Sights, Individual
FY	fiscal year
GCV	Ground Combat Vehicle
GVS&FP	Ground Vehicle Survivability and Force Protection
HF	hydrogen fluoride
HFC-227ea	Fire Extinguishant Gas also commonly known as FM-200 - 1,1,1,2,3,3,3-Heptafluoropropane, also called heptafluoropropane, HFC-227 or HFC-227ea.
HFI	Human Factors Integration
HSI	Human Systems Integration
HMMP	Hazardous Materials Management Program
HMMWV	high-mobility multipurpose wheeled vehicle
HQDA	Headquarters Department of the Army
HRED	Human Research and Engineering Directorate
ICD	Initial Capabilities Document
IO	information operations
JAGM	Joint Air to Ground Missile
JCIDS	Joint Capabilities Integration Development System
JETS	Joint Effects Targeting System
JLTV	Joint Lightweight Tactical Vehicle
JPM NBC	Joint Project Manager for Nuclear, Biological and Chemical Contamination
LATP	Lima Army Tank Plant
LFTE	Live Fire Test & Evaluation
MANPRINT	Manpower and Personnel Integration
MOD	Ministry of Defence
MRMC	Medical Research & Materiel Command

NFPA	National Fire Protection Association
NPS	Naval Post Graduate School
NRC	National Research Council
OSD	Office of the Secretary of Defense
PAL	Parameter Assessment List
PEO	Program Executive Office
PGK	Precision Guidance Kit
PIM	Paladin Integrated Management
PM	program manager
PMO	project management office
POC	point of contact
RSP	Required System Performance
SLAD	Survivability/Lethality Analysis Directorate
SMMP	System MANPRINT Management Plan
S&P	survivability and occupant protection
SSv	Soldier survivability
SSvA	SSv assessment
TAB	Technical Advisory Board
THAAD	Terminal High-Altitude Area Defense
TLDS	Target Location Designation System
TRADOC	Training and Doctrine Command
TUA	Targeting Under Armor
TTPs	tactics, techniques, and procedures
USAACE	US Army Aviation Center of Excellence
WIPT	Working Integrated Product Team
WMRD	Weapons and Materials Research Directorate
WSMR	White Sands Missile Range

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