MANPRINT Quarterly

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The Director's Corner

Part I. The Meaning of "Integration" and a Shift in the Army's Lead Integration Organization.

The term "integration" in Manpower and Personnel Integration and in Human Systems Integration carries distinctive meanings which imply distinctive perspectives for MANPRINT analyses. Three levels of a hierarchy of integration analyses are described here.

Total System Integration (TSI) is at the top of the hierarchy. The TSI purpose is to examine the allocation of functions to the human component of the total system (e.g., a truck driver reads his paper map to decide his trucking route, as compared to the truck following a homing signal), or to the machine component (the truck's drive assembly does all of the work to move the truck), or to any highly interactive human-machine functions (steering the truck). The initial Comanche design work had a focal issue in TSI — could the system be designed so that traditional navigator functions would be allocated to the machine to reduce the number of operators from two to one?

MANPRINT- Machine Integration (MMI) examines all of the seven MANPRINT domain analyses to detect patterns with implications for redesign emphasis. For example, let's consider a new vehicle design for which the Human Factors analysis concludes that the level of heat in a crew compartment may seriously lower operator vigilance and response times, the Safety analysis concludes that risk of operator error is raised by heated working conditions, the Soldier Survivability analysis concludes that escape may be impeded by extremely hot passage ways, and the Health Hazards analysis finds that hot plastics may contaminate air needed for breathing; whereas a PM might be inclined to minimize the need for changes if only one of the domains identified a given problem

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Meeting of Interest

TAG 38

12–15 May 1997
Menger Hotel
San Antonio, TX

Hosted by:

Brooks Air Force Base
San Antonio, TX

POC:

Ms. Sheryl Cosing
Commercial: 703-925-9791

IMPRINT

The Transition and Further Development of a Soldier-System Analysis Tool

by

Dr. Laurel Allender
Mr. Troy Kelley
U.S. Army Research Laboratory

Ms. Sue Archer
Micro Analysis & Design

Mr. Rich Adkins
Dynamics Research Corporation

At first glance, the Improved Performance Research Integration Tool (IMPRINT) appears to be simply the Windows™ version of the DOS™-based Hardware vs. Manpower III (HARDMAN III) suite of soldier-system analysis tools. However, the transition from DOS™ to Windows™ was more than just a re-coding exercise. It was an opportunity to be guided by user input, by research findings, and to rethink the underlying structure, functionality, and interrelationships of the analytic capability being offered. This article surveys the course of IMPRINT development, from concept to initial design and prototype to first user release—IMPRINT 2.8.7—and beyond.

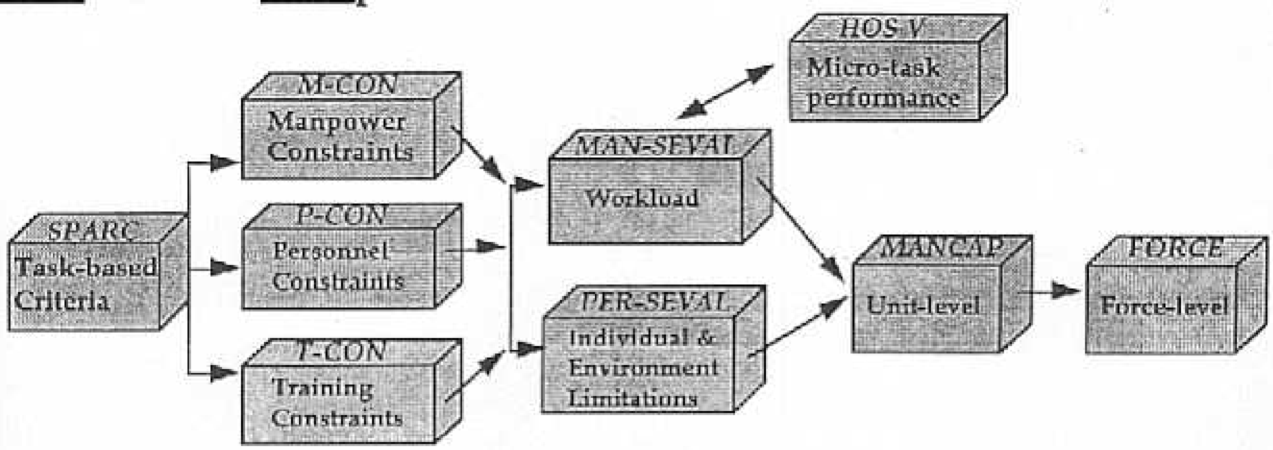
Early History. Given that IMPRINT is the "Windows™ name" for HARDMAN III, it is worth a few words to examine the origins of that tool. HARDMAN III grew out of common Air Force, Navy, and Army manpower, personnel, and training (MPT) concerns identified in the mid-1970's: How to estimate MPT constraints and requirements early on in system acquisition and how to enter those considerations into the design and decisionmaking process. The Navy first developed the HARDMAN Comparability Methodology (HCM). The Army then tailored the manual HCM, which became known as HARDMAN I, for application to a broad range of weapon systems and later developed an automated version, HARDMAN II.

In HARDMAN I and II, however, there was no direct link between MPT and performance. Therefore, when development of the first HARDMAN III modules began in 1985, providing an explicit link between MPT variables and soldier-system performance was one of the primary goals. In an innovative contracting process, 18 separate concept papers were written proposing diverse analytic approaches. These 18 were down-selected to ten specifications, and then to six implementation proposals. Ultimately from those six, a set of nine separate modules was developed by three contractors: Dynamics Research Corporation, Micro Analysis & Design, and Applied Sciences Associates. A listing of those nine modules and their respective functionalities is shown in the figure on the next page.

A guiding notion in the development of the HARDMAN III modules was that the analysis would proceed in a fairly "lock-step" fashion. The analyst would be led from one module to the next, and within a module, from one step to the next in order. Using HARDMAN III would go something like this (for the original discussion, see Kaplan, 1988): For a given system, the analyst would first use HARDMAN III during pre-concept development to help identify the early system requirements. Then, the concept and requirements would be passed through MPT "filters" to help identify any constraints on continued development such as limited crew availability, competition for annual maintenance manhours with other systems, limits on soldier quality, or potential increases in training resources required.

Once system concept development was completed and the demonstration and validation phase had begun, HARDMAN III could be used to evaluate the design. For example, either a design described in a contractor proposal or a prototype system could be evaluated with respect to the numbers of operators and/

Hardware vs. Manpower



Definitions

SPARC:	System Performance & RAM (Reliability, Availability, & Maintainability) Criteria Estimation	MAN-SEVAL:	Manpower-based System Evaluation
M-CON:	Manpower Constraints Estimation	PER-SEVAL:	Personnel-based System Evaluation
P-CON:	Personnel Constraints Estimation	MANCAP:	Manpower Capabilities
T-CON:	Training Constraints Estimation	FORCE:	Force-level
		HOS V:	Human Operator Simulator V

HARDMAN III modules and functionality

or maintainers required by that design to meet the original system requirements. As an option, the analysis could be subjected to a series of "what-if's" such as how the requirements and performance would change under heat stress, in protective clothing, or with different soldier personnel characteristics. Finally, the system-level analysis would be rolled up at the unit and the force levels.

In practice, however, HARDMAN III users employed whichever module best fit the system issues at hand whether or not the earlier analyses had been done, even tailoring and adapting the tool capabilities to fit their needs. In the process then, certain subtleties of the individual HARDMAN III modules were overcome by events, or rather, overcome by users! Also, computer technologies and the acquisition process itself were changing rapidly.

IMPRINT Development: From Front-End Analysis to Prototype. When the transition from the HARDMAN III DOS™ version to a Windows™ version was first discussed, the motives were to keep pace with computer technology both in terms of processing speed and power and also in terms of the more usable and exciting interface that graphics offers. A front-end analysis was conducted to map the nine HARDMAN III modules into a single software product (Adkins & Dahl, 1992). Through the analysis, redundancies across the modules that were "forced" by the DOS™ limitations and unintentional differences that "just happened" because of the DOS™ environment were identified, as well as improvements that would come "automatically" with the Windows™ environment.

The DOS™ limitation of only 640K of Random Access Memory (RAM) had forced the design of the original HARDMAN III modules so that "pieces" of the analyses could fit within these RAM blocks. Since HARDMAN III analyses are task-based, the amount of data to be managed at any one time had to fit under the RAM constraints. This led to a restriction of 400 operations tasks and 500 maintenance tasks per model. The RAM limitation also meant that identical or similar data and capabilities had to be offered in multiple modules, but with some tailoring to suit the purpose of the module. For example, in HARDMAN III, the same library models and system data are resident in seven

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out of the nine modules (a fact that drove the hard drive storage space requirement to nearly 80 MB!). Also, the task network modeling engine, MicroSaint, was accessed in six places in four modules, two of the cases being identical, the other four requiring somewhat different input data.

Although the redundancy was intentional, most of the discrepancies and differences across the modules were unintentional. Many differences occurred because the "correct" design decision for one module was the wrong decision for another module. For example, in some places the use of a specific Military Occupational Specialty (MOS) was merely a label; in other places it referenced actual data derived from the Enlisted Master File. Also, in some places, a reference to environmental conditions served only as a notecard; in other places, it activated embedded performance degradation algorithms.

The "automatic" improvements that Windows™ provided (it should be noted, however, that a lot of work goes into making something automatic!) were in two main areas: the graphical orientation and the compatibility with other software applications. The graphical orientation provided a more intuitive framework for thinking about and building the task networks used in most IMPRINT analyses. The compatibility with other software applications provided shortcuts for cutting and pasting between IMPRINT and standard word processors, spreadsheets, and graphics packages. It also provided an implicit cost-savings because the capabilities of those other applications did not have to be recreated inside IMPRINT.

In keeping with good design practices, the next step was to prototype the IMPRINT screens. For a brief moment, we envisioned a menu with options named for the HARDMAN III modules—"SPARC," "M-CON," etc. However, since the artificial divisions—and naming—of the analytic capabilities were no longer necessary, various other concepts for the structure of the menus were drafted. After considerable brainstorming, two different concepts were prototyped. One menu structure was "goal-oriented" and the other was "function-oriented." In the first case, the proposed high level menu structure was intended to fit what the user's goal would be when conducting an analysis.

File	Edit	Goals	Constraints	Evaluation	Reports	Help

In the second case, the proposed high level menu structure was intended to fit what functionality the user wanted, no matter what the specific analysis question.

File	Edit	Define	Options	Execute	Reports	Adjust	Help

In order to decide between these two designs, a series of evaluations took place.

Prototype Evaluation. In the series of usability evaluations, three groups of participants used five different techniques to evaluate the prototypes. The first group used the individual walkthrough. The second group used a combination of an empirical evaluation, an heuristic evaluation, and a group walkthrough. The third group used the pluralistic walkthrough. Below, brief descriptions of these evaluations are provided. (For a complete discussion, see Kelley & Allender, 1996; also Dahl, et al., 1995.)

Individual Walkthrough with Initial Prototypes. Prototype screens for the two options were developed in Toolbook™. An executable copy of the screens and a packet that included printouts of every screen, as well as a sheet of instructions and a comment sheet, were distributed to current, active HARDMAN III users who would have an understanding of the underlying capabilities to be included in IMPRINT. The individuals receiving the packets were asked to respond to direct questions about the interface such as, "What changes should be made to the layout of the prototype?" They could use the comment sheet or make comments directly on the printouts. Based on the comments, numerous changes were made to the designs of both prototypes. These changed prototypes were used in the next three evaluations.

Empirical—or Experimental—Evaluation. For this experimental evaluation, the updated Toolbook™ prototypes were also "fleshed out." In this way, the prototypes not only looked like real software but, in some cases, even acted like real software. Twenty participants were asked to perform ten "real-life" tasks using each of the prototypes, for example, "Find the screen where task networks are built." The prototypes were presented in different orders to different participants to avoid any bias based simply on order of presentation. Data were collected using a video camera and using time and accuracy collection tools embedded in the prototype.

In addition to the specific interface and design problems uncovered by reviewing the video taped actions and comments of the participants, an overall view of performance and the ease-of-use of the two prototypes was given by the time and accuracy data. The time and accuracy data are shown below. It can be seen that the function-oriented design was both faster and required fewer mouse clicks to accomplish the tasks than did the goal-oriented design. The differences can be explained not only by the relative efficiency of the two designs, but also by how many errors the participants made and had to recover from before continuing.

Time and accuracy data for the two prototypes.

	Goal-Oriented	Function-Oriented
Average Number of Seconds per Task	97.97	79.58
Average Number of Mouse Clicks per Task	5.29	4.03

Heuristic Evaluation. Participants were given usability guidelines—or heuristics—to help guide them through an evaluation of the prototypes. The guidelines were that software should (1) be simple and have natural dialog, (2) speak the user's language, (3) minimize user memory load, (4) be consistent, (5) provide feedback, (6) provide clearly marked exits, (7) provide shortcuts, (8) provide good error messages, and (9) prevent errors (Neilson & Molich, 1990). The subjects were instructed to use the guidelines to identify usability problems as they reviewed each prototype.

Group Walkthrough. Participants met in one room with a large monitor displaying the prototype. A moderator walked through the screens, performing the task lists used for the empirical evaluation. Subjects raised any concerns they had, and data were collected using video camera and notes.

A Design Decision. The comments from the empirical, heuristic, and group evaluations were collected and reviewed. The number and severity of the interface problems identified were considered along with the time and accuracy data. As a result, the function-oriented menu structure was selected as the one to be developed for IMPRINT. The goal-oriented menu structure was found to suffer from many of the same artificial naming and redundancy problems as HARDMAN III. The function-oriented menu structure turned out to be more "generic" and to better fit the steps of a broad range of analysis goals. Also, getting away from jargon was important since IMPRINT users are likely to be part-time users. Therefore, the interface—the terminology and the structure—was required to be as intuitive and obvious as possible.

Pluralistic Walkthrough. Even though a menu structure had been decided, the usability evaluations continued. The prototype of the function-oriented design was updated to incorporate the results of the previous evaluations. It was then demonstrated to a group of 18 people consisting of end users, human factors experts, developers, and programmers. Because the group included a mix of expertise, it is defined as "pluralistic" (Bias, 1991). This meeting actually constituted what was the first IMPRINT Steering Committee meeting. Group comments were recorded in the minutes of the meeting, and the moderator strove for consensus on the detailed design decisions that were suggested.

An Interesting Side Note. The different usability techniques were sensitive to uncovering different types and numbers of problems. The individual walkthrough technique identified a total of 39 unique problems, significantly more than any other technique. However, when looking at the severity of the problems as rated on a three-point scale, the most severe problems were identified by the empirical method. As you can see, the individual walkthrough technique identified the highest number of low severity problems. Understanding the differences across techniques will be useful in the future when deciding which technique to use for an assessment.

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IMPRINT

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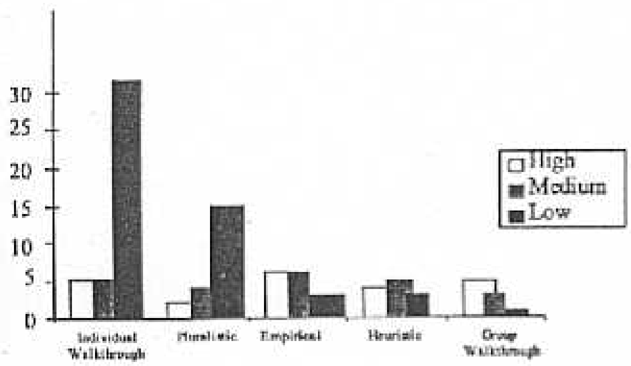

Number of problems identified by severity

IMPRINT 2.8.7. Next, the "real work" began. The design was taken from prototypes to actual code. To continue to guide the design, two more Steering Committee meetings were held as well as numerous in-house reviews and testing sessions. Over 300 additional comments have been logged. Remarkably though, the interface design stayed basically the same. This serves as a testament to the utility of doing prototypes and early reviews. If the same problems had been found with actual code, they would have been quite costly to fix.

IMPRINT 2.8.7 was made available to users in October 1996. It contains an estimated 90% of the analysis capability of the original HARDMAN III modules. It is also faster, easier to use, easier to install, and requires less hard drive storage space. Redundancies and discrepancies have been eliminated. What-if analyses are easier because successive analyses can all be done with the same piece of software instead of moving the analysis from one module to the next. In short, the transition from the DOS™ environment to Windows™ is complete—and none too soon. As acquisition is streamlined and Army budgets are trimmed, the need for this type of analysis has not diminished, but the timelines for doing them have.

IMPRINT Version 3 and Future Planning. To continue to support the analysts with an ever-more efficient and effective IMPRINT, Version 3 was delivered to ARL HRED in December 96 for internal testing, the most significant change being the introduction of the WinCrew capability for advanced workload analysis. Using this capability, rather than being limited to a "parallel" assessment of mental workload and performance, a link can be made between the two. Conditions can be set so that if workload exceeds a defined threshold, performance is affected. It can be affected by slower performance, more errors, changes in task allocation, etc.

Enhancements being discussed for a potential Version 4 include, among other things, a training support package, more environmental stressor options to extend the "what-if" capabilities, additional maintenance modeling features, the development of graphical aids for data input, tighter links to manpower costing tools, and updated personnel data to match that found in FOOTPRINT. Also, the verification, validation, and accreditation program, the first phase having been accomplished for HARDMAN III, will be continued for IMPRINT (see Allender, et al. 1995).

The next Steering Committee meeting is being planned for Spring 97. For more information about the software or the upcoming meeting, please contact the U.S. Army Research Laboratory Human Research & Engineering Directorate, Attn: AMSRL-HR-MB, Aberdeen Proving Ground, MD 21005-5425 (phone 410-278-6237, 6233, or 5883, DSN 298).

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(excessive heat in our example), the consistent pattern of problems across domains should motivate attention to the underlying problem.

Cross-Domain Integration (CDI) is generally a cross-check from one domain to another to determine consistency and to estimate the desirability of system design changes. For example, if equipment configuration makes it "difficult" for an operator to perform and if the difficulty also creates a need for "extensive" training and practice, then a consistent analysis is generated that strongly implies a need for design changes.

Lead Integration Agency Shift. An organizational shift has now been arranged concerning the Army's lead MANPRINT organization for integration analyses. Most recently, PERSCOM was missioned to routinely work integration for TRADOC Integrated Concept Teams and for Integrated Product Teams, with the Human Research and Engineering Directorate (HRED) of the Army Research Lab conducting integration analyses when prompted by specific human factors issues. A reduction in the staff at PERSCOM has led the DCSPER to authorize HRED to take the MANPRINT lead for integration. PERSCOM will continue to conduct Manpower, Personnel, and Training analyses for the purpose of preparing the MPT Assessment, and manage the Army's MANPRINT Training Program.

All domains are encouraged to conduct integrative analyses when they see a need, but HRED now has the primary role in performing integrative analyses. HRED will also collect reports from all of the MANPRINT domains and draft the ODCSPER's MANPRINT Assessments for ASARCs when necessary to resolve persisting issues.

Part II. Name Change for the MANPRINT Directorate.

Army Regulation 70-1, Army Research, Development, and Acquisition, Army Acquisition Policy, designates the ODCSPER to be responsible for overseeing and executing the Army's Soldier-Oriented R&D (SORD) efforts. The majority of the programs encompassed by SORD are in the Army Research Institute (ARI) and HRED. The DCSPER has recently missioned the MANPRINT Directorate to execute his SORD responsibilities, given their frequent close relationships with MANPRINT interests. To signify the MANPRINT Directorate's additional mission, we have been renamed the Personnel Technologies (PERTEC) Directorate.

Jack H. Hiller
Director for Personnel Technologies

MANPRINT Training Schedule

MANPRINT Action Officers Course

CLASS #	DATES	LOCATION
97-001	12 May - 22 May 97	Fort Lee, VA
97-702	12 Aug - 21 Aug 97	Redstone Arsenal, AL

MANPRINT Applications Course

MANPRINT Applications Courses are tailored from 1 to 5 days in length with a focus on customer needs. These courses are given by special request.

CLASS #	DATES	LOCATION
97-708	25 Feb - 28 Feb 97	Fort Bragg, NC
97-704	6 May - 9 May 97	Redstone Arsenal, AL
97-705	24 Jun - 27 Jun 97	Fort Gordon, GA
97-707	5 Aug - 8 Aug 97	Fort Leonard Wood, MO
97-706	9 Sep - 12 Sep 97	Fort Hood, TX
97-703	30 Sep - 3 Oct 97	Rock Island Arsenal, IL

POC: MAJ Carmody or SFC Raveneau (703) 325-1560, DSN 221-1560 or (703) 325-8422, DSN 221-8422

Summary of Results
MANPRINT Practitioner Training Questionnaire

by
Ms. Diana Lueker
Office of the Deputy Chief of Staff for Plans, Force Integration and Analysis
U.S. Total Army Personnel Command
and
Mr. Lanny Walker
Remtech Services Incorporated

The results of the MANPRINT Practitioner training questionnaire are in. The questionnaire was part of an ongoing evaluation and planning process to ensure the continued accessibility and value of MANPRINT training in the rapidly-evolving Army systems acquisition environment. It was administered under the aegis of the MANPRINT Division, Office of the Deputy Chief of Staff for Plans, Force Integration and Analysis, U.S. Total Army Personnel Command (DCSPLANS, PERSCOM), in coordination with the Army Logistics Management College (ALMC), U.S. Army Training and Doctrine Command (TRADOC). The Directorate for MANPRINT, Office of the Deputy Chief of Staff for Personnel, Department of the Army, assisted in the design and review of the study questionnaire.

The questionnaire solicited practitioner opinions on the usefulness and content of MANPRINT training. It also asked participants to provide information about their MANPRINT duties, responsibilities, and activities. Three hundred twenty-three practitioner-level questionnaires were mailed and 170 responses were received—an excellent 53% response rate. Most of the questionnaires were sent to personnel in the MANPRINT Quarterly mailing list and the 1995 MANPRINT Directory; some other addressees were selected individually because of their recognized MANPRINT expertise. This was the first known solicitation of training input from a broad sample of MANPRINT practitioners. Not only did we gain valuable insights about the current and future training programs, but we also got a broad-based understanding of just who the current practitioners are and what they do.

Participants Profile

Responses to the questionnaire indicated MANPRINT practitioners perform a wide range of functions and activities. They are a mix of MANPRINT program managers, logisticians, MANPRINT domain specialists, other analysts, and acquisition program managers. The primary MANPRINT duty or duties reported by the questionnaire participants are summarized in Figure 1.

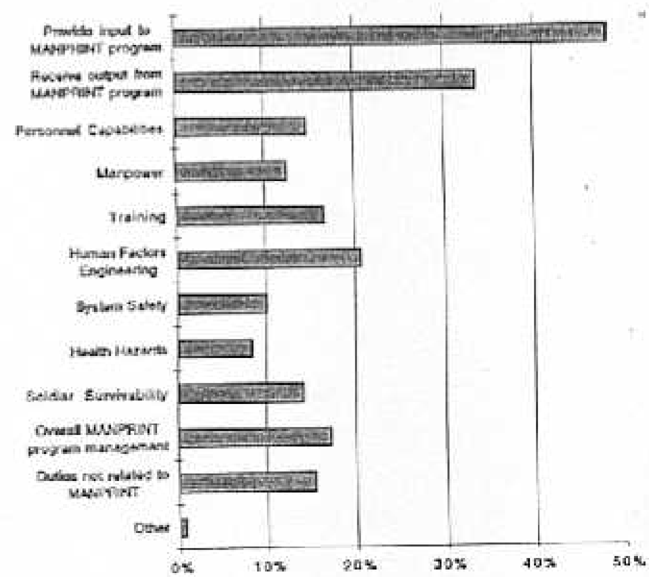

Figure 1. MANPRINT Duties and Responsibilities

Only 17% of the respondents indicated that their primary duty was overall MANPRINT program management. In contrast, 48% said they provided input to the MANPRINT program for one or more systems, and 34% said they received output. The greatest domain representation was for human factors engineering (21%). Fifteen percent of the respondents believed that their duties were not related to MANPRINT.

The questionnaire participants had extensive MANPRINT experience. Fifty-six percent had 3 years or more and another 20% had between 1 and 3 years. Only 9% reported none. Figure 2 summarizes the MANPRINT experience reported on the questionnaires.

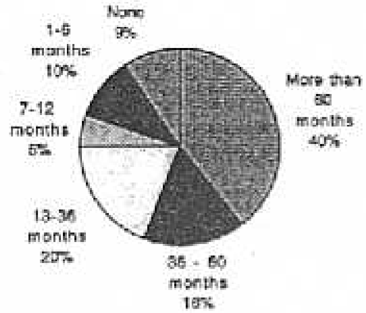

Figure 2. MANPRINT Experience

Value of Initial MANPRINT Training

Respondents believed that MANPRINT training is valuable. The 140 respondents who had had training, either in a MANPRINT course or as part of another course, were more positive about its value than the 30 respondents who reported having had no training. Nevertheless, both groups had a positive opinion overall.

Initial MANPRINT Training Content

Questionnaire participants rated potential areas of instruction in initial MANPRINT training according to the degree of benefit to them. The priority scale was:

3. High Priority—Greatest benefit
2. Moderately High Priority—Significant benefit
1. Moderate Priority—Useful if time available
0. Do not need

Figure 3 presents the percentage of respondents rating the potential areas of instruction at least moderately high priority—a "3" or "2" rating.

At least 50% of the respondents rated all but two areas, "Manpower" and "Application of MANPRINT in AIS programs," as at least moderately high priority. Manpower was so rated by only slightly below 50%. The lower ratings for AIS are probably attributable to the relatively few respondents who have AIS responsibilities.

MANPRINT Training in the Future

Planning for future MANPRINT training strategies is still in progress. Thanks again to the questionnaire participants for sharing your experience and insights. MANPRINT training plans, progress, and changes will be reported in future editions of the MANPRINT Quarterly.

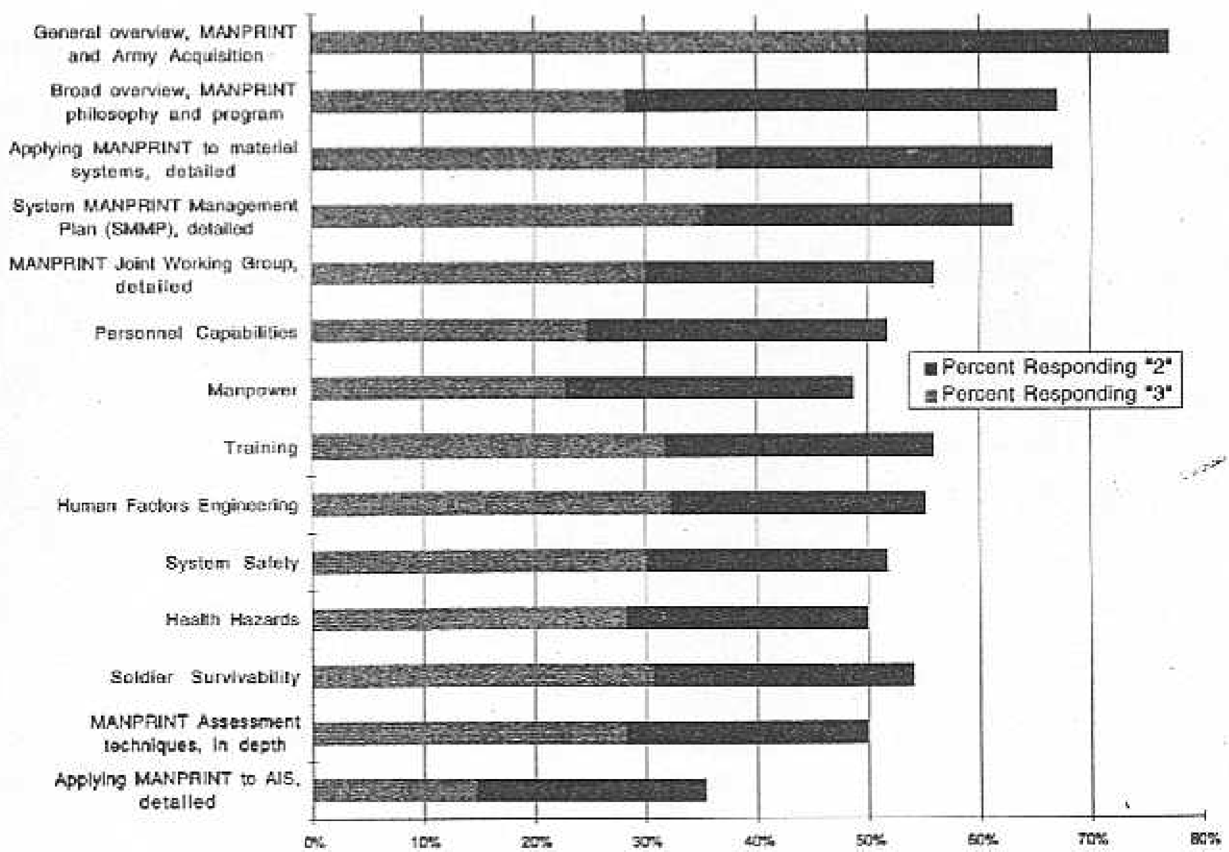

Figure 3. Percent of Respondents Rating Indicated Training Areas "3"—Very High Priority or "2"—Moderately High Priority