LOCATING HUMAN SYSTEM TECHNOLOGIES FOR THE ACQUISITION PROCESS

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ABSTRACT

To maximize cost benefit savings, influence design, and facilitate the trade-off decision process, the requirements for manpower, personnel, training, safety, health hazard prevention, and human factors engineering must be addressed as early as possible in the acquisition cycle. To ensure that human issues are integrated into the total system, the new DoDI 5000.2, "Defense Acquisition Management Policies and Procedures" requires analysis and reporting of these factors throughout the acquisition process. A NATO Research Study Group (RSG.21) was formed to identify, define, and describe the tools, techniques, and databases that enhance early consideration and integration of human issues at appropriate acquisition milestones. RSG.21 developed the term "Liveware" to collectively describe the domains of manpower, personnel, training, safety, human factors engineering, and health hazard prevention. Liveware is defined as the human component of a weapon system in its integrated environment. Collection of descriptive information about existing and emerging Liveware technologies is being accomplished by the Office of the Secretary of Defense under the auspices of RSG.21. This effort involves industry and government developers, owners, and users. The resulting collection will represent the most complete automated catalog of international Liveware technologies available. Access to the catalog is to be provided to the entire acquisition community. This paper (1) describes the requirements for and importance of human system information during the acquisition process; (2) defines the Liveware domains; (3) summarizes previous collections of information; (4) describes the need for a Liveware database; (5) describes the concept and scope of the database which produces standardized Liveware data, the information available, and methods for accessing the catalog; and (6) summarizes the benefits to the acquisition community from use of the data.

ABOUT THE AUTHORS

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BACKGROUND

The process of designing and acquiring defense systems can be noticeably improved by early identification of the requirements for manpower, personnel, training, safety, health hazard prevention, and human factors engineering and by full participation in the trade-off process. The attention paid to these factors will ensure that issues relating to the human can be integrated into the total system at all levels of the process. Each human-related factor must be addressed as early as possible in the acquisition cycle to maximize cost benefits, influence design, and facilitate the trade-off decision process.

DoD Requirements

The new Department of Defense Instruction (DoDI) 5000.2, "Defense Acquisition Management Policies and Procedures," and DoD 500.2-M, "Defense Acquisition Management Documentation and Reports," requires the effective integration of human considerations into the design effort to improve total system performance and reduce life-cycle cost. Objectives for the human element are to be established at Milestone I, and assessed, refined, and updated throughout the process.

NATO Defense Research Group

NATO Defense Research Group Panel 8, "Defense Applications of Human and Bio-medical Sciences," established Research Study Group 21 (RSG.21), "Liveware Integration in Weapon System Acquisition," to study how the human-machine interface was addressed and resolved by member nations during design, development, and acquisition of weapon systems. Participating nations include Canada, France, Germany, the Netherlands, United Kingdom, and United States. See Figure 1.

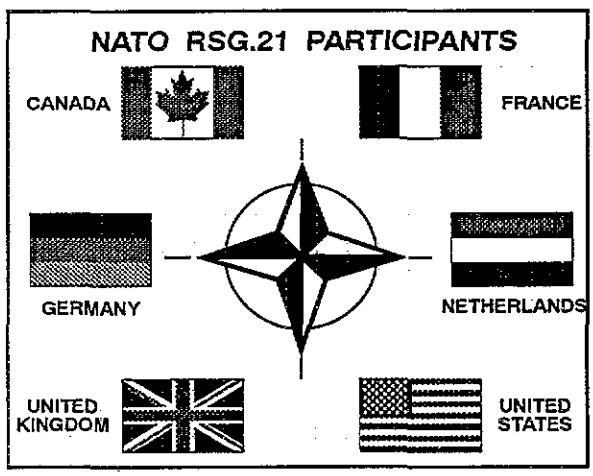

Figure 1. Participating NATO Nations

RSG.21 Task

RSG.21 is chaired by Lt Col Michael Pearce of the Office of the Assistant Secretary of Defense (OASD), Force Management and Personnel (FM&P), Requirements and Resources (R&R), Total Force Requirements (TFR), Human Systems Integration (HSI) office. RSG.21 was tasked to identify, define, and describe the tools, techniques, and databases that enhance early consideration and integration of human issues into the total system; evaluate the findings; and identify gaps and voids for future research and development (R&D) efforts.

Liveware

RSG.21 developed the term Liveware to collectively describe the human-related domains of manpower, personnel, training, safety, health hazard prevention, and human factors engineering. Figure 2 displays the logo which symbolizes the Liveware concept of six domains integrated in an atom structure, the center of which is the human.

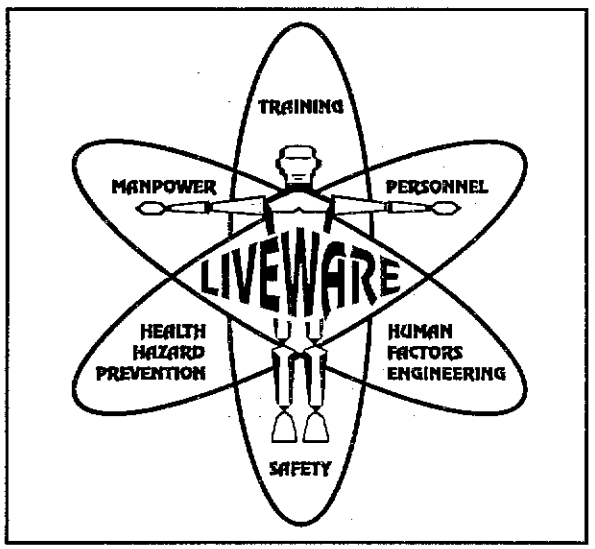

Figure 2. Liveware Logo

Tasking

To document existing and emerging Liveware technologies identified by the participating NATO nations and arrange the information into formats suitable for practical use and reporting requirements, the Department of Defense Training and Performance Data Center (TPDC) was tasked by OASD (FM&P)/R&R (TFR) HSI office to develop the data collection instruments and master database, collect Liveware data, and maintain the online data system.

LIVEWARE DOMAINS DEFINED

Liveware is defined as the human component of a defense system in its integrated environment. Liveware Integration describes the iterative process of analyzing, designing, assessing and combining human elements with hardware and software to create a total system. See Figure 3.

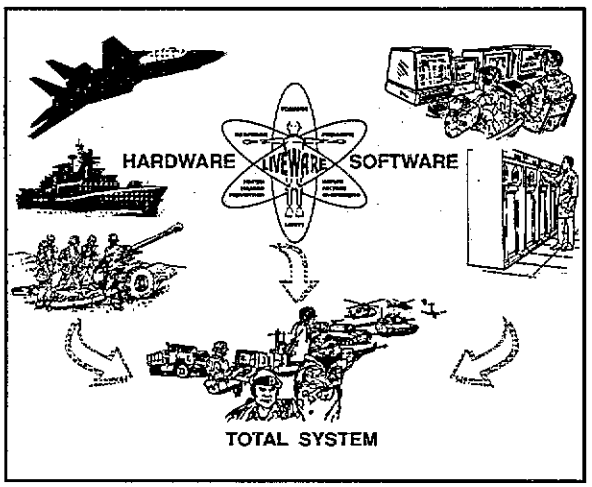

Figure 3. Major Parts of An Integrated System

Definitions

The following definitions for the domains which comprise Liveware have been designated and approved by RSG.21. They were developed to meet the needs of the international NATO acquisition community and essentially support those found in DoDI 5000.2 and its referenced documents.

- Manpower is the demand for human resources, expressed in terms of numbers and organizations required for the operation and support of a system. A manpower requirement is the number of human resources needed to accomplish operational tasks of organizations or units.
- Personnel defines the human in terms of occupation, skill level, experience, and physical attributes. Personnel requirements include those military and civilian persons, at the skill level and grade required to perform a given set of tasks, in peacetime and war.
- Training is the process by which personnel acquire or enhance specific skills, knowledge, abilities, and attitudes required to accomplish tasks to a specified performance level.
- Safety is defined as the freedom from those conditions that can cause death or injury to personnel, damage to or loss of equipment or property, or damage to the environment.
- Health Hazard is defined as an existing or likely condition, inherent to the operation or use of

material, that can cause death, injury, acute or chronic illness, disability, and/or reduce job performance/productivity of personnel. Health hazard prevention is the avoidance of the condition.

- Human Factors Engineering is the area of human factors which applies scientific knowledge to the design of items to achieve effective human-system integration. Human factors are defined as the body of scientific facts about human capabilities and limitations which includes the principles and applications of human engineering, personnel selection, training, life support, job performance aids, and human performance evaluation.

LIVEWARE DURING THE ACQUISITION PROCESS

HSI Requirements

The specific requirements for human system information are found throughout DoD 5000.2 and 2-M. All program and document references stress the need to establish requisites, objectives, and considerations early in the acquisition process; and require refinement and update during each phase of acquisition. They begin at Milestone 0 with the requirement to identify any existing human systems constraints for the Mission Need Requirement document and are an integral part throughout the acquisition process. Other programs or documents state the requirement as follows:

- Human Systems Integration - *"Human considerations shall be effectively integrated into the design effort for defense systems to improve total system performance and reduce costs of ownership by focusing attention on the capabilities of the soldier, sailor, airman, or marine. Objectives for the human element of the system shall be initially established at Milestone I ... and subsequently refined and updated at successive milestone decision points."*

- Human Factors - *"Human factors engineering shall be an integral part of planning and conceptual efforts, development projects, and acquisition programs to include modifications. The capabilities and limitations of the operator, maintainer, trainer, and other support personnel should be identified early enough in the design effort to impact the design."*

- System Safety, Health Hazards, and Environmental Impact - *"Appropriate system safety and health hazard objectives shall be established early in the program and used to guide system safety and health hazard activities and the decision process."*

- Integrated Logistics Support - *"Manpower, personnel, training, and safety are essential de sign, human systems integration and support considerations. They will be given explicit at tention early in the acquisition process."*

- Test and Evaluation - *"Test planning must begin in Phase 0 ... and must address all system components (hardware, software, and human interfaces)."*

Program/Document List

A list of the documents and programs which contain references to and requirements for various Liveware domains appears in Figure 4.

- Mission Need Requirement (MNS)
- Operational Requirements Document (ORD)
- Test & Evaluation Master Plan (TEMP)
- Human Systems Integration Plan (HSIP)
- Integrated Program Summary (IPS)
- Manpower Estimate Report (MER)
- System Training Plan (STP)
- Human Factors Program (HFP)
- System Safety Program (SSP)
- Integrated Logistics Support (ILS)

Figure 4. Documents and Programs Related to HSI Requirements

Appropriate Phases And Milestones

The Liveware-related documents and programs listed above are shown in Figure 5 by acquisition milestone and phase. The chart points up the fact that all except the MER are initially required by Milestone I.

Human Considerations

Central to the design and development of defense systems are the needs and requirements

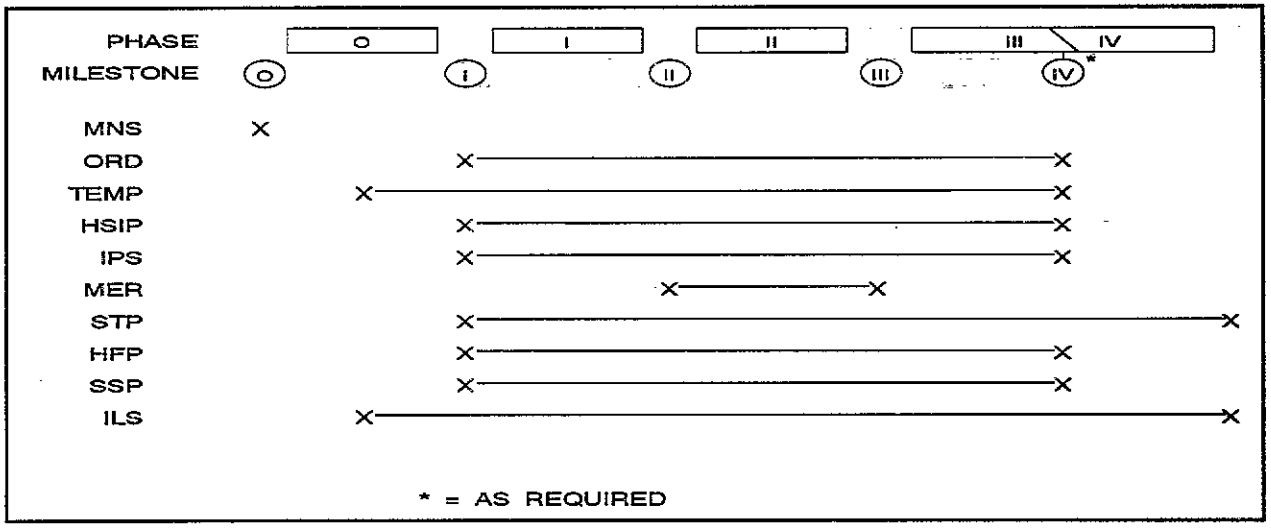

Figure 5. Documents & Programs by Acquisition Milestone/Phase

of the human user. No system should be planned, designed, or acquired without people and equipment being given equal consideration throughout the acquisition process.

Cost Considerations

Performance and cost factors can be influenced in a positive manner when addressed early in the acquisition process. Studies done by the U.S. General Accounting Office have shown that up to 70 percent of a system's life cycle costs are determined by decisions made during Concept Exploration. Close to 60 percent of weapon system life cycle costs are people and associated training requirements-related (Graine, 1988). Figure 6 displays this concept. MANPRINT, the Army human systems integration implementation program, "subscribes to the idea that investment in the front end on human factors will provide paybacks tenfold in the long term" (Booher, 1990).

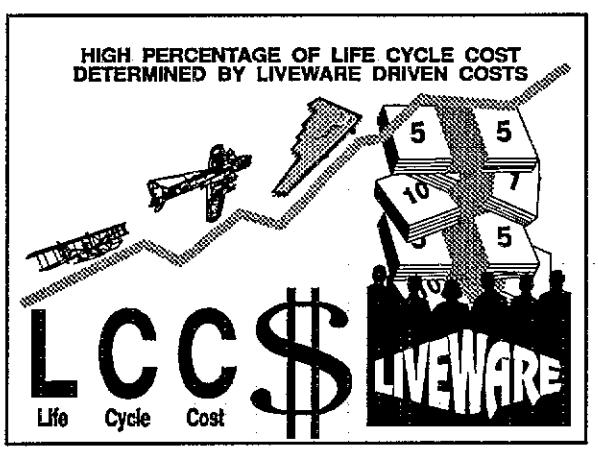

Figure 6. Liveware Life-Cycle Costs

PREVIOUS HSI TOOL SURVEYS

Previous Data Collection Efforts

There have been previous efforts to collect and categorize the tools, techniques, and databases related to the Liveware domains. None have been comprehensive of all domains and all Services. Lack of publicity across academic/service disciplines in many cases has prevented full participation and full use of the resulting product. No universally accepted central location exists where information about all available options can be obtained. Table 1 contains a summary of some previous efforts which detailed available Liveware tools and databases. The table depicts critical areas covered, or not covered, by the most current surveys of Liveware-related technology.

THE NEED FOR A LIVEWARE DATABASE

RSG.21 Requirement

A comprehensive survey of current Liveware information from all sectors of the international acquisition community was required to meet the objectives of the RSG.21 task. In addition, the data

Table 1. HSI Survey Efforts

EFFORT	LIVEWARE Domains Covered							Service			Tool/Technologies Covered						
Title Author(s) Corporation Sponsor Date (Related studies follow each other)	Manpower	Personnel	Training	Safety	Health Hazards	Human Factors Engineering	Logistics	Air Force	Army	Navy/Marine Corps	Non-Automated	Automated	Tool	Database	MIL-STD/HDBK	REGs/Pamphlets/Guide	Facilities
Advanced Human Factors Engineering Tool Technologies Fleger, Permenter, and Malone, Carlow Associattes, Inc. U.S. ARMY Human Engineering Lab (USAHEL), 1988.						F		C	F	C	C	F	F	IF INCORPORATED IN TOOL			
Integrated Decision/ Engineering Aid (IDEA), Carlow International, Inc, USAHEL	C	C	C			F		C	F	C	C	F	F	IF INCORPORATED IN TOOL	IN OTHER, IDEA TOOLS	REFERENCED IN OTHER IDEA TOOLS	
Analysis Of MPT(S) During Acquisition of AF Systems. Rossmeissl, Akman, Kerchner, Faucheux, Wright, Shields, and Waldrop, Hay Systems, Inc. AF Human Systems Division (AFSC). 1990	C	C	C				C	F	C			F	F	F			
AF Human Systems Integration Tools and Databases. Gentner, Aeronautical Systems Division (ASD) Manpower, Personnel, & Training Directorate (ALH). 1991	F	F	F	C	C	C	C	F			C	F	F	F	C		
Directory of Design Support Methods, Bogner, Kibbs, Lanine, Hewitt, Army Research Institute, MANPRINT Office, DoD HFE Technical Group (TG), 1990.	F	F	C			F	C	C	F	C	F	F	F	F	F	F	
Logistics Support Analysis Techniques Guide (AMC Pamphlet 700-4) US ARMY Materiel Command (AMC) Materiel Readiness Support Activity 1991.	F	C	C				F	F	F	C	C	F	F			F (PRIMARILY ARMY)	
Survey of Manpower Personnel Software Development Tools. Bravo and Bakalarski Dynamic Research Corporation,Computer-Aided Acquisition & Logistics Support (CALS) Human Systems Components (HSC) Committee. 1991	F	F					C	F	F	C		F	F				
Survey of CALS Training Development Software Tools. Wall and Tucker, Raytheon, Inc. CALS HSC Committee. 1990			F				C	F	F	F		F	F				
Liveware Integration in ... Acquisition: Review of Canadian Organization, Tools, & Technologies. Beevis, Canadian Defence & Civil Institute of Environmental Medicine, Human Factors Division, 1991.	C	C	C	C	C	F		C (CANADIAN SERVICES WITH REFERENCES TO U.S. TOOLS)	C	C	C	F	C		C	C	
DoD Liveware Survey Crissey and Gentner, CSERIAC and TPDC. OASD(FM&P)/R&R(TFR) HSI Offices. 1992 (In Progress)	F	F	F	F	F	F	C	F	F	F	F	F	F	F	F	C	F

F = Focus
C = Covered To Some Extent

was needed in an automated format to easily produce information identifying gaps and voids in Liveware technologies which would then be recommended for NATO prioritization of research and development efforts designed to close those gaps.

HSI Requirement

With the advent of HSI directives such as DoDI 5000.2, many potential users were searching for better and more efficient methods to meet these directives. A comprehensive survey to gather current Liveware information from all sectors of the acquisition community, researchers and industry, and an accessible, automated system to present HSI tool and database information was needed.

CALS HSC Sub-Group Requirement

"Computer-Aided Acquisition and Logistics Support (CALS) is a DoD and Industry strategy to enable, and to accelerate, the integration of digital technical information for weapon system acquisition, design, manufacture, and support." The focus of the CALS Human Systems Components (HSC) Sub-Group has been to emphasize the process of converting from paper to digital-flow data, databases, and analyses for all HSC components (those domains collectively known as Liveware). The Liveware database will support several CALS-HSC objectives and initiatives. These include the following:

- Reduce Time through the sharing and easy location of information regarding the human system (Liveware) components of defense systems.

- Reduce Cost through eliminating development of redundant or unnecessary tools/data bases and data needed to meet acquisition milestones.

- Identify Available Tools which can enhance acquisition process efficiency and productivity and make this information readily available throughout the acquisition community.

User Requirement

There are many tools, techniques, and databases available within the Liveware domains. However, those which are available may not be fully utilized. Many available, useful, and effective technologies suffer from lack of exposure. If you are an acquisition manager, logistics/HSI analyst, human factors engineer, or researcher, do you know which databases and tools can assist in conducting the required HSI analyses during systems acquisition? Today's answer is by conducting searches and referencing many documents, and you may still miss some. Tomorrow's solution is to conduct a survey of all HSI tools, techniques, and databases; place the results in an easily accessible database; and make the information available in catalog, computer diskette, and on-line formats. When the Liveware survey and database are complete, there will be an effective answer to the problem faced recurrently by HSI focal points and their defense system contractors.

LIVEWARE DATABASE CONCEPT AND SCOPE

Starting Point

The Liveware database is meant to be a starting point in the process of developing manpower, personnel, training, safety, health hazard and human factors engineering information to meet DoD human systems integration requirements. It provides the most complete listing of international Liveware technologies available.

Assessment Aid

In terms of weapon system acquisition, the database will facilitate assessment of NATO member nation weapon systems by standardizing Liveware data and terminology. Its use will enhance the international sharing of information, technologies, and tools. The database will be used to support RSG.21 identification of technology gaps, and prioritize NATO R&D efforts to close those gaps.

Technology Choice Aid

The database does not rate or rank individual programs, nor provide descriptive information in great detail. It does provide enough information to the analyst, program manager, or developer to narrow the list of appropriate tools to those which would be of value for the particular domain, task or acquisition phase. When provided with a broad range of information in an easy-to-query summary format, the user can narrow the search for appropriate tools very quickly. After receiving point of contact (POC) information about both tool developer and user, pursuing in-depth information about a particular tool is easily accomplished.

LIVEWARE DATABASE CAPABILITIES

Liveware Database

The Liveware database has three major sections of data: general program information, domain-specific descriptive information, and owner/user information. The on-line information may be reviewed by individual program or displayed in various pre-programmed report formats. In addition, a capability exists to print the reports in hardcopy.

General Program Information

There are ten major areas of information in this section. Program Identification includes the program name, acronym, description, type of technology, country of origin, community sector, state of development, availability, accessibility, and portability. The Purpose and Acquisition Phase covers mission area, system area, system and force level, and acquisition phase. The next three areas include Hardware Requirements, Software Requirements, and Linkages to other tools/databases. Documentation displays the names and dates of technical reference and user instruction docu-

ments, data output mode, and availability of data file descriptions and data record layouts. The Validity area contains product validation information. The final three areas are text fields displaying Assumptions, Limitations, and Remarks.

Descriptive Information

This section contains information identifying the Liveware domains addressed by the program, applicable categories within each domain, and environmental areas of concern to safety and health hazard programs. If the program integrates several programs, the method of integration (vertical and/or horizontal) is specified.

Owner/User/Point Of Contact Information

This section covers multiple areas. Not only is the owning organization identified with a point of contact (POC) but multiple users of the program and their organizations are also identified. For each POC, the following information is available: organization name, address and telephone number, user work discipline, domains applied, and frequency of use.

Reports Available

Pre-programmed reports include all the information for individual programs in a catalog format, lists of all programs in the database by name, by Liveware domain, by type, and by purpose and acquisition phase. The query function allows a keyword search on program titles and descriptions for topic information. The reports were designed to allow database users to quickly narrow the search for appropriate tools. Figure 7 shows a sample report which lists programs by name with applicable acquisition phase and Liveware domain.

LWARDDIP-14-1 LIVEWARE DATA BASE INFORMATION SYSTEM 06/08/92
REPORT FOR PROGRAMS BY ACQUISITION AND APPLIED DOMAINS

LIVEWARE PROGRAMS	* ACQUISITION PHASE *							* APPLIED DOMAINS *						
	N/R	C/D	P/D	D/D	PRD	M/D	******	M	P	I	S	H	E	T
ARMY TRAINING REQUIREMENTS AND RESOURCES SYSTEM				X				X	X	X				
AUTHORING INSTRUCTIONAL MATERIALS				X	X					X				
COMPREHENSIVE OCCUPATIONAL DATA ANALYSIS PROGRAMS	X	X							X	X				
COMPUTER AIDED SYSTEMS HUMAN ENGINEERING			X	X									X	
COMPUTERIZED BIOMECHANICAL MAN-MODEL	X	X											X	
COURSEWARE CONFIGURATION MANAGEMENT						X				X				
CREW CHIEF		X				X							X	
CREW REQUIREMENT DEFINITION SYSTEM		X	X	X	X	X		X	X	X			X	
CREW SYSTEM ERGONOMICS INFORMATION ANALYSIS CENTER	X	X		X				X	X	X	X		X	X
EARLY COMPARABILITY ANALYSIS		X	X						X	X				
ENGINEERING DESIGN GRAPHICS				X									X	
ENLISTED AFSC REGULATION	X	X				X			X					
FOOTPRINT		X		X	X	X		X	X	X				X
HARDMAN II.2	X	X	X			X		X	X	X				
HARDWARE MANPOWER INTEGRATION	X	X	X	X				X	X	X				
HUMAN OPERATOR SYSTEM			X	X	X	X			X				X	
INSTRUCTIONAL DESIGN ASSISTANT				X						X				
INSTRUCTIONAL SYSTEM DEVELOPMENT DATA BASE				X		X			X	X				
INSTRUCTIONAL SYSTEMS CONSULTANT						X				X				
INTEGRATED PERCEPTUAL PROGRAM INFORMATION FOR DESIGNERS	X	X		X	X								X	
JOINT SERVICE ISD/LSAR DECISION SUPPORT SYSTEM	X	X	X	X	X	X				X				
LEARNING OBJECTIVES CLASSIFICATION TOOL		X		X		X				X				
LESSONS LEARNED DATA	X									X				
LOGISTIC COMPOSITE MODEL	X	X		X	X	X		X	X				X	
MANPOWER AND PERSONNEL INTEGRATION DATA BASE	X	X						X	X		X	X	X	
MANPOWER BASED SYSTEM EVALUATION AID				X				X						
MANPOWER CONSTRAINTS AID		X	X					X						
MILITARY TRAINING SYSTEM ANALYSIS MODEL	X	X	X	X						X				
OCCUPATIONAL RESEARCH DATABASE	X	X	X	X	X	X		X	X	X				
PEAKS COURESBUILDING, LESSONBUILDING & EXAMBUILDING SOFTWARE				X	X					X				
PIPELINE MANAGEMENT SYSTEM	X	X	X	X	X	X				X				
SYSTEM PERFORMANCE AND RAM CRITERIA AID	X							X						
TEST GENERATOR				X						X				
TRAINING ANALYSIS SUPPORT COMPUTER SYSTEM			X	X						X				
TRAINING COST DATA ENHANCEMENT SYSTEM	X					X				X				
TRAINING REQUIREMENTS/ATTRIBUTES CONCURRENCE EVALUATION SYS		X	X	X										

Figure 7. Sample Liveware Database Report

ACCESSING THE INFORMATION

On-Line Review

The database will come on-line in March 1993 and will be available for review to both Government and Industry via dial-in capability by modem, Defense Data Network (DDN), or Internet. The contact number will be publicized throughout the HSI community and provided to database contributors at that time.

Liveware Technology Guide

The database will support development of a Liveware Technology Guide. This guide will document in a hardcopy printout format all Liveware program information contained in the database in a catalog format. The Technology Guide will be available by written request after March 1993.

CONCLUSIONS

Benefits For The Acquisition Community

Table 2 displays some of the benefits to the acquisition community which can to be derived from use of the Liveware database. They include shared knowledge of applicable international Liveware technologies in a standardized format and identification of appropriate technology information in one location. Information previously found only in a patchwork quilt of references will now be available in one easily accessible database. Users will find information about HSI tools quickly and more efficiently.

Summary

As HSI technologies become easier to locate, select, and use, more appropriate HSI analyses will likely be conducted. The design and decision process should be enhanced. The result of earlier and more comprehensive use of HSI technology should be more cost-effective, safer, and easier-to-train weapon systems which more reliably meet human performance requirements.

Table 2. Liveware Database Benefits

Liveware Database Quality	Benefits
Comprehensive	One Data Source, Rather Than Many; One Effort Used For Many Purposes
On-line/On Diskette Access	Quick & Efficient Access, Time Saver, Most Current Information
Index & Cross-References	Easy To Identify Appropriate Technology
Standardized Format	Easy to Compare & Contrast Technologies
POC & User Identification	Obtain Balanced Point of View, Detailed Information, Application Information
NATO-Wide Information	Promotes Sharing Technology, Innovative Approaches

REFERENCES

Alluisi, E.A. (1990). Computer-Aided Acquisition & Logistic Support - Human System Components (CALS-HSC). Presentation at Human-Centered Design Technology for Maintainability: A Workshop. Alexandria, VA: Institute For Defense Analysis.

Beevis, D. (1991, June). Liveware Integration in Weapon System Acquisition - Review of Canadian Organization Tools and Technologies. DCIEM Report No. 91-47. Defence and Civil Institute of Environmental Medicine. North York, Ontario.

Bogner, M.S., Kibbe, M., Lanine,R., Hewitt, G. (1990, November). Directory of Design Support Methods. (Developed under the

auspices of the Designing for the User Subgroup of the DoD HFE Technical Group.) Washington, DC: Headquarters, Department of the Army, ODCSPER, MANPRINT Directorate.

Booher, H.R. (1990). Introduction: The MANPRINT Philosophy. In MANPRINT, An Approach to Systems Integration, (pp.1-16). New York: Van Nostrand Reinhold.

Bravo, T. and Bakalarski, L. (1991, November). Survey of CALS Manpower and Personnel Development Software Tools. (Developed by The CALS Human System Components Committee.) Wilmington, MA: Dynamics Research Corporation.

Department of Defense (1990, September). Military Handbook Department of Defense Computer-Aided Acquisition and Logistic Support (CALS) Program Implementation Guide (MIL-HDBK-59A). Washington, DC.

Department of Defense (1991, February). DoD 5000.2, Defense Acquisition Management Policies and Procedures, (Part 4, Section B, Part 6, Sections H & I, Part 7, Sections A & B, *Part 8)*. Washington, DC.

Department of Defense (1991, February). *DoD 5000.2-M,* Defense Acquisition Management Documentation and Reports, *Parts 2, 3, 4, 6, and 7.* Washington, DC.

Department of Defense (1991, November). Technical Reference Model for Corporate information Management. Washington, DC: Defense Information Systems Agency, Center for Information Management.

Fleger, S.A., Permenter, F.E., and Malone, T.B. (1988, March) Advanced Human Factors Engineering Tool Technologies *(TM 2-88)*. Aberdeen Proving Ground, MD: U.S. Army Human Engineering Laboratory (AD-A195252).

Gentner, F.C. (1991). AF Human Systems Integration (HSI) Tools and Databases. In William G. Beazley (Ed.), The Contractor's Guide to CALS and Concurrent Engineering. Washington, DC: Pasha Publishing.

Gentner, F.C. (1991, May). Survey of AF MPTS Tools and Databases for Human Systems Integration. Proceedings of the National Aerospace Electronics Conference (NAECON), 2, 824-831. Dayton, OH: Institute of Electrical and Electronics Engineers.

Graine, G.N. (1988). The Engineering Syndrome vs. The Manpower Personnel and Training Dilemma. Naval Engineers Journal, 54-58.

Rossmeissl, P., Akman, A., Kerchner, R., Fauch G., Wright, E., Shields, J., and Waldrop, G. (1990, October). Analysis of Manpower, Personnel, Training and Safety During Acquisition of AFSystems: Requirements and Capabilities (VII,II,III) (HSD-TR-90-022). Brooks AFB, AF Human Systems Division, Deputy for Development Planning.

U.S. Army Materiel Command (1991, February). Logistics Support Analysis Techniques Guide (AMC-P700-4). Alexandria, VA.

Wall, J. (1991, December). Survey of Training Development Software Tools. (Developed by The CALS Human System Components Committee.) Burlington, MA: Raytheon Service Company.

Wall, J. and Tucker, R. (1990, December). Survey of CALS Training Development Software Tools. (Developed by The CALS Human System Components Committee.) Burlington, MA: Raytheon Service Company.