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# The T800 Engine:
## A MANPRINT Success Story

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APW, a joint venture between United Technologies Pratt & Whitney and Textron Lycoming, successfully applied MANPRINT philosophy to the design and development of the APW T800 engine candidate for the LHX/T800 engine competition. MANPRINT was in its infancy in 1985 when the LHX engine competition contract was released; although requirements were much less defined then than today, the T800 represents a significant application of MANPRINT to a major Army weapon system acquisition.

APW applied MANPRINT using a basic three point model: Plan, Organize, and Implement. To provide the guidance for implementing MANPRINT, a System MANPRINT Management Plan (SMMP) was developed using AR 602-2, "Manpower and Personnel Integration (MANPRINT) in the Materiel Acquisition Process," as a reference. The SMMP was updated twice during the program.

An autonomous MANPRINT team was formed, with the MANPRINT Manager on an equal status with that of the Reliability, Availability, and Maintainability (RAM) and Integrated Logistics Support (ILS) managers. The MANPRINT team became part of a checks and balance system that included MANPRINT analysis; Problems, Issues and Concerns (PIC) tracking; and sign-off on all trade stud-

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# MANPRINT
## Success Stories

We have two MANPRINTsuccess stories in this issue: one concerns the T800 engine candidate for the LHX, the other concerns MANPRINT training courses. In addition, we offer several articles that detail how MANPRINT analyses have been used to assess a weapon system's ability to accommodate the needs of its users.

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ies, design reviews and Problem Identification Reports (PIRs).

MANPRINT was implemented through a matrix management model with each MANPRINT discipline acting as an independent function, but integrated through the MANPRINT team and the MANPRINT Joint Working Group (MJWG). This model paralleled contract and Source Selection Evaluation Board (SSEB) evaluation requirements. A Design Criteria Memo was then developed under Logistics Support Analysis (LSA) Task 205 (Supportability and Supportability-related Design Factors) to establish MANPRINT goals and objectives and identify engineering design requirements and constraints. This document then became the beat to which the overall APW team marched in designing the T800 for supportability, thus ensuring that MANPRINT was designed in...not added on.

The MANPRINT process began by sensitizing APW designers and logistics personnel to the soldiers' "real world" environment through visits to Army user and depot-level installations. Subsequent visits to these installations included use of a mock-up APW T800 engine. During these visits, interviews with more than 600 soldiers were conducted to obtain their comments concerning the design and supportability features. This feedback provided data to ensure that the current engine design and any future changes were consistent with the goals set forth in the Design Criteria Memo. These contractor/Army interfaces were critical to putting and keeping the "man in the loop."

The trade study process, along with supportability design reviews, provided important methods by which MANPRINT influenced engine design. Trade studies served to alert MANPRINT personnel to potential conflicts with goals and objectives before actual hardware development. Supportability design reviews ensured that supportability and related design requirements, set forth in the Design Criteria Memo, were kept in the forefront of the design process and incorporated in the resulting configuration. The MANPRINT team had input and sign-off responsibility on all trade studies and design reviews.

Specific MANPRINT analyses were performed on each Line Replaceable Unit (LRU) and Module identified in the Logistic Support Analysis Record, (LSAR). A number of the parameters of this analysis parallel those for man-machine interface enhancements proposed in the new MIL-STD-1388-2B, "Department of Defense (DOD) Requirements for LSAR Record." A MANPRINT sensitivity analysis was performed, when necessary, to evaluate the effect of interdiscipline trade-offs to meet MANPRINT goals, objectives, and design requirements specified in the Design Criteria Memo.

A preliminary training analysis was performed as part of LSA Task 203 (Baseline Comparison Analysis). At that time, it was forecasted that because of the maintainable design and high reliability of the APW T800, combined with the requirement for a two-level maintenance concept, training would be minimal and could probably be limited to New Equipment Familiarization Training. The training requirements analysis conducted as part of LSA Task 401 (Operational and Maintenance Task Analysis) confirmed the early forecast.

Maintainability/Human Factors demonstrations provided MANPRINT personnel with an opportunity to validate MANPRINT concepts. Helicopter Powerplant Repairers, Military Occupational Specialty (MOS) 68B and other Career Management Field (CMF) 67 MOS male and females, of different anthropometric profiles, skill levels, experience, and aptitudes, were used to perform user-level maintenance tasks. These tasks were performed in Battle Dress Uniform (BDU), Mission Oriented Protection Posture (MOPP IV), and arctic gear; in daylight and dark conditions; and in a mockup LHX engine nacelle. The anthropometric profile and Armed Forces Qualification Test (AFQT) personnel requirements were met during these demonstrations. The demonstrations verified that both MOS 68B and other CMF 67 MOSs were capable of performing the APW T800 user-level tasks with no increase in training burden and no noticeable difference in task time or difficulty.

Analysis of the demonstrations, workload and manpower forecast, ease of maintenance, and the two-level maintenance concept showed that a significant savings in the Army force structure could be achieved by using an LHX Helicopter Repairer instead of 68B Powerplant Repairer to maintain the T800 under a two-level maintenance concept.

Problems, Issues, and Concerns (PICs) resulting from analyses, trade studies, design reviews, and demonstrations were entered into the MANPRINT

PIC data file. The MANPRINT team ensured that each issue resulted in a Problem Identification Report (PIR), or trade study. To ensure management visibility, a MANPRINT "hit list" of the top PICs was published weekly.

An overall MANPRINT objective of the APW team was to answer the Army's question: Can this soldier, with this training, perform these tasks, to these standards, under these conditions? (See Figure 1 below.) Findings of MANPRINT analyses, by domain, are as follows:

**Manpower/Personnel.** Only one maintainer was needed to remove any LRU, and, at the most, two maintainers to remove any module. MOSs other than 68B were able to maintain the T800. In addition, MOS consolidation was recommended.

**Training.** The new Equipment Familiarization Training was found to be adequate, and interactive video training can serve for sustainment training.

**Human Factors.** All modules were found to be within weight and size limits for handling by no more than two male or female maintainers. All LRUs were within weight and size limits for handling by no more than one male or female maintainer. Fluid and electrical connections were designed for operation with arctic and MOPP IV gloves. All LRUs were configured for one-way installation. No field adjustments were needed for performance. All bolts were torqued equally and visually, with no torquing tools required. LRUs requiring frequent removal are accessible without disturbing adjacent LRUs. Design includes a full-capability diagnostics system.

**System Safety/Health Hazards.** External cases minimize cavities and pockets which collect dirt, oil, and contaminating materials. Sharp/pointed edges were removed from components to prevent personal injury. Loose hardware was reduced through the elimination of lockwire and cottor pins and the use of captured non-standard bolts and O-ring seals. Lockwire was deleted to reduce personal injury. NBC/corrosion resistant material and coatings increase the life of the engine parts, and all external fasteners are

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| QUESTION: | ANSWER: |
|---|---|
| *Can this soldier . . .* | • Tasks were performed by the 5th-95th anthropometric profile female/male<br>• Tasks were performed by the AFQT Category IV soldier for the target audience MOS<br>• Workload is sufficently small, combined with ease of maintenance and tasks similar to those of MOS 67 led to MOS consolidation recommendation<br>• Non CMF 67 MOS (63E) demonstrated capability in performing user-level tasks |
| *With this training . . .* | • Training burdens considerably decreased because of simplified tasks<br>• MOS consolidation will not increase training burden<br>• Non CMF MOS could support T800 with minimal training<br>• Interactive video courseware will provide Army flexibility in use to ensure immediate and sustained proficiency training |
| *Perform these tasks . . .* | • Tasks are neither physically nor mentally demanding<br>• Design features reduce the possibility of error<br>• Tasks are short and consolidated |
| *To these standards . . .* | • Tasks successfuly demonstrated surpassed goals and objectives |
| *Under these conditions . . .* | • Tasks successfuly demonstrated in arctic clothing and MOPP IV gear<br>• Tasks successfully demonstrated on the bench and in mock-up engine bay in darkness |

**Figure 1. MANPRINT Successfully Answers the Question**

# VIRTUAL MOCKUP

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*Editor's Note: This article is an edited version of a draft chapter written for an upcoming book on MANPRINT. Dr. Harold Booher, Director, MANPRINT Office, ODCSPER, is editing the book, which will be published in the Spring of 1990.*

Computer-aided design (CAD) provides a new environment for implementing MANPRINT philosophy, focusing research, and improving the transfer of technologies in the human performance dimension. Modern CAD systems translate designs into "electronic mockups" which can then be quickly and accurately evaluated for user accommodation using new anthropometric design tools. Without such tools, these types of evaluations are rarely cost effective or of sufficient quality.

To aid in task visualization for a developmental crew-operated system, the Army is developing a tool, called VIRTUAL MOCKUP, that will allow designers or evaluators to create an animated task sequence showing the complex interactions between the crew and system. System dynamics and interactions are often not well understood during concept development. Engineers may have equations describing the dynamics of a new system, but have no way of visualizing them. VIRTUAL MOCKUP not only provides a viewing mechanism, but also a timeline of the activities to aid in task analysis. Further, a preliminary hazard evaluation is often produced from the information provided by the animation.

The VIRTUAL MOCKUP program incorporates two other programs: the Ptech model developed by Associative Design Technology, and the JACK model developed by the University of Pennsylvania. Automation Research Systems, Limited (ARS), is integrating these programs to form the VIRTUAL MOCKUP system.

The Ptech program provides the framework for defining complex task sequences in a natural-language, flowchart form. The boxes of the flowchart are linked to tailored script sequences which drive the animation of the task described in each box. Ptech allows the user to enter salient knowledge (actions, movements, situations, etc.) and the user's concept of the work setting and work segments. Each task segment is represented by a single block of the diagram, which can have alternative paths at each node. When all are defined, the user simply selects a path through the diagram to assemble the entire task sequence. Each path represents a variation of the task sequence scenario.

The JACK portion of VIRTUAL MOCKUP animates the sequence defined by Ptech. JACK provides visualization for the activity sequence in 3-D color using a Silicon Graphics IRIS display system. This digital animation yields much more information than does a video tape of an actual task. Every frame has time and precise 3-D geometry representing not only the workplace, but also the posture of each of the workers in the complex task sequence. Interactions among the workers can be inspected at any scale and resolution, and can be replayed and reanalyzed as required. The animation can be viewed from any angle or, by partitioning the screen, from multiple viewpoints simultaneously on the single display screen.

VIRTUAL MOCKUP is being linked to a Measure of Effectiveness (MOE) model developed by ARS and Communications Technology Applications (CTA) under contract to the Army Human Engineering Laboratory (HEL). The MOE model is a PC program linked to the IRIS workstation through UNIX windows. The activity sequence generates and passes parameters to the MOE model, which computes and displays performance parameters associated with the action.

VIRTUAL MOCKUP is best used where real prototypes are expensive. Its primary value is not in an experimental environment (predictive), but rather for concept exploration and for synthesis and presentation of optimal findings. The system supports interactive modifications in system design and rapid visualization, resulting in an integration of information spread over many people, steps, and time.

## VIRTUAL MOCKUP Applications

**Problem: Why is the Dragon Anti-tank missile difficult to fire accurately?**

The Dragon is a TOW (Tube-launched, Optically tracked, Wire-guided) missile. The missile is in a disposable tube with a bipod support on the front of the tube. The operator sits on the ground and holds the rear of the launch tube on his right shoulder, and aims the weapon by moving the aft-end of the tube by posture adjustment. To change the aim to the left, the operator must shift his upper body to the right. During the missile flight, the operator must continue to aim the sight at the target. The optical sight senses the deviation between the missile's position and the line-of-sight to the target and sends steering corrections to the missile through wires that trail out of the aft end of the missile. In other words, the missile follows the aim of the sight. The operator wraps his right arm under, around, and over the tube to reach the trigger. When the missile is fired, the noise far exceeds the maximum allowable for impact noise, and the operator is briefly enveloped in the exhaust flash and smoke.

**Application: The Dragon firing sequence is programmed into the VIRTUAL MOCKUP program.**

Initially, the program user can select to view the scenario from the Dragon operator's viewpoint, that is, through the optical sight. When the simulated launch is initiated, several of the problem conditions can be demonstrated and recorded.

- Most of the 28 pound weight of the Dragon system disappears when the missile fires, causing the operator to recoil upward, sometimes steering the missile into the ground. With the weight and inertia of the launcher changing so drastically, the feel of tracking the target prior to and after firing are completely different. To counter this change, the operator should pull the tube down against his shoulder with about 150 pounds of force to minimize the recoil effects. If the dynamics of this recoil are programmed into the VIRTUAL MOCKUP scenario, the effect on aim is clearly visible in the through-the-sight-view of the scenario.

- In the first seconds after firing, the missile appears larger in the sight than does the target. The missile exhaust is bright and attention getting, whereas the target is camouflaged and difficult to see against the background. Sometimes the Dragon operator begins tracking the missile, causing the missile to fly off course, missing the target. If the VIRTUAL MOCKUP tracking equations are programmed to track the missile, the effect on aim is clearly visible in the through-the-sight-view of the scenario.

- Because breathing while the missile is in flight causes the aim to deviate, operators must hold their breath 12 to 25 seconds during final aiming, firing, and missile flight. This may not be easy if the soldier was running just prior to firing. When the dynamics of breathing are programmed into the VIRTUAL MOCKUP scenario, the effect on aim is clearly visible in the through-the-sight-view of the scenario. Inadvertent launch tube movement of one degree causes the aim to deviate off the target by 9 meters at a typical firing range of 500 meters. The VIRTUAL MOCKUP shows deviations of several degrees due to breathing.

- Oversteering is bad for two reasons: (1) it may exhaust the missile's limited rocket fuel before reaching the target, and (2) a miss may be inadvertently commanded because operators are not accustomed to performing precision steering with trunk movements. To change the aim, the operator must crouch downward to lower the rear of the tube. When the dynamics of steering lag and oversteering are programmed into the scenario, the effect on aim is clearly visible in the through-the-sight-view. The simulation can also compute the difference between the actual flight path in the simulation and the ideal straight-line path.

The VIRTUAL MOCKUP program operator can also view the scenario from the side, where other problems can be seen. Selecting a 5th percentile body size shows that smaller-than-average operators can just barely reach the right arm around the tube to the trigger. Even though the smaller people can reach the trigger, the stretching action limits their body mobility for aiming. Again, the operator can pull the tube down against his shoulder with about 150 pounds of force to minimize the recoil effects. Generating this much force, however, stresses the same arm and trunk muscles which must be used simultaneously for precision aiming and tracking. Despite the adverse effect on tracking, suddenly releasing the gripping force could cause an even larger deviation. Also, while the operator is pulling the tube down onto

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# MANPRINT Training: A Success Story

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*"As available resources continue to dwindle, it is more important than ever that we maximize the returns we receive for every dollar invested in an acquisition, and MANPRINT can help save us a lot of money in the future . . . so it is imperative that we do MANPRINT right. The Army has known for some time that we couldn't design a system and then try to jam people into it. When that happens, you are putting the cart before the horse, and it flat won't work. In today's fiscal environment, we just won't get the dollars needed to redesign equipment, so we have to do things right the first time. MANPRINT has got to be driven by believers. And how do you make them believers? By doing MANPRINT training; by getting the requirements guy and the developer to sit down together and talk through the MANPRINT process."*

*MG Stephen R. Woods, Jr.*
*Commander, Soldier Support Center*

The Soldier Support Center (SSC), Fort Benjamin Harrison, Indiana, was appointed the Army-wide proponent for MANPRINT training in October 1987. The Soldier Support Center-National Capital Region (SSC-NCR), located in Alexandria, Virginia, was given the mission to execute MANPRINT training. Department of Defense (military and civilian) personnel and industry are eligible to attend the two formal MANPRINT courses. The MANPRINT Senior Training Course (MSTC) is designed for upper and mid-level management, while the MANPRINT Staff Officer Course (MSOC) is intended for action officers. These courses have trained over 2100 people to date.

The MSTC is taught at TRADOC and AMC installations. One of the course functions is to have the senior and mid-level leadership from a TRADOC school sit down with their counterparts from AMC and industry. This gives each command a better appreciation of each other's roles during materiel acquisition. During the course, a system common to each group is covered to provide a focal point for the week-long instruction. The host installation commanding general or his representative normally opens the course with a personalized briefing on how host senior and mid-managers view their part in the materiel acquisition process. Because interaction is the key to a well-rounded learning experience, attendees work through a practical exercise designed to facilitate an exchange of ideas between the two commands.

The MSOC, taught at Fort Belvoir, Virginia, is designed to give action officers a basic knowledge of materiel acquisition and MANPRINT implementation at the installation level. During the three-week course, the students study such topics as the Life Cycle Systems Management Model, the budgeting process, the six MANPRINT domains, program and requirements documents, organizations involved in the acquisition process and the importance of conducting MANPRINT analyses early-on.

After a course orientation, MSOC students are given a diagnostic test on MANPRINT and materiel acquisition. Initial test scores naturally reflect the individual's previous experience. (Missing three out of every four questions is not uncommon!) In addition, students get an idea of their strong and weak areas and the type of questions that they may expect on the two MSOC examinations.

MSOC graduates agree that the course is a challenge. Additional study time after class is encouraged, as is group study to enhance the student's learning experience. Students are required to pass the two examinations in order to graduate. A review is given prior to each exam to help ensure that students have learned the lesson objectives. Instructors are also available after class for additional assistance, if necessary.

Experience has shown that it is important for students to represent a cross section of the acquisition community in order to promote a healthy exchange of information. To facilitate this, the MANPRINT training office has made a concerted effort to balance the experience and organizational background of the attendees from AMC, TRADOC, and industry in each session. Hearing how the "other guy" does things provides a well-rounded learning experience and gives new insight into how materiel acquisition is accomplished.

Student course critiques are an important element within the MSOC. They provide valuable and timely comments which are given careful consideration in course direction and content. Based upon these critiques, presentations are changed to better instruct the class, material is updated to keep up with the rapidly changing fields of MANPRINT and materiel acquisition, and instructors get a better understanding of how the different class participants view their roles in MANPRINT.

MANPRINT training has been well received by the acquisition community as an aid which enhances the process of the soldier-machine interface. Course graduates depart with a feeling that early-on MANPRINT analyses can make a difference. Influencing design helps ensure that we field systems to meet the Army's needs. Continued success can only be maintained by the combined support of Army and industry. Alternate means of training are being considered to bring MANPRINT training to the widest possible audience. Exportable training packages that provide on-site training, training modules for all service schools, and non-resident training courses are some of the ideas being considered for implementation in the immediate future.

MANPRINT has come a long way since its inception in 1984, however, its focus remains constant: To equip the soldier to fight and win on the battlefield. We must always be able to answer positively when asked the question: Can this soldier, with this training, perform these tasks, to these standards, under these conditions? As we look to the 1990's and beyond, we will continue to keep the soldier and his capabilities at the forefront when designing new materiel systems. This will ensure that MANPRINT continues as a success story!

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**VIRTUAL MOCKUP** (continued from page 5)

the shoulder, the eye may not line up with the sightpiece. This also varies with body size. A side view of the scenario shows how well the eye and eyepiece line up for different sized operators.

In summary, VIRTUAL MOCKUP can help the designer visualize and understand some of the very complex interactions in using a weapon system. This tool does not predict action, but rather describes preprogrammed activities. The dynamic models (breathing, oversteering, etc.) which describe each of these interactions do not exist at this very early stage of VIRTUAL MOCKUP development. Each model must be custom-made and linked to the program. Later, if one of these is useful in another case, the user can select it from a library of tasks rather than create it from scratch as must now be done.

In developing an animated sequence scenario using VIRTUAL MOCKUP, all the information is accumulated necessary for task analysis and operator and maintenance manuals, therefore providing a double utility for a developmental system.

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made of the same material to prevent installing the wrong fastener.

In short, asking MANPRINT-kinds of questions and resolving any resulting concerns during the design and development of the T800 engine served to ensure that the engine could be safely and easily maintained by the numbers and types of soldiers specified by the Army. The T800 engine is truly a "MANPRINT" success story before its time. Pratt & Whitney believes in and practices MANPRINT principles and is eager to work with the Department of Defense to incorporate the intent of DOD Directive 5000.53, "Manpower, Personnel, Training and Safety (MPTS) in the Defense System Acquisition Process," in its everyday business.

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# Implications of System Test Data for Training Resource Decisions

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A critical training issue facing decisionmakers concerns the resources necessary to achieve the required level of soldier proficiency on a weapon system. Preliminary training decisions influence the training support in institutional and unit training throughout the system's life. What can be done to lower the decision-making risk?

Systems must be designed so that training problems are reduced, thereby minimizing the number and complexity of training issues to be resolved. Many approaches can and are being used; this article focuses on two types of data available from system tests: task difficulty and information on the training programs which prepare soldiers for tests.

**The Predecessor System: The Dragon**

As part of a training impact analysis on the Advanced Antitank Weapon System-Medium (AAWS-M), training resource and soldier proficiency information available from historical test data on the predecessor system, the Dragon, was obtained. Training on AAWS-M prototypes was also observed. System tests were particularly valuable because the special measures of soldier proficiency obtained in such tests are not always available during institutional or unit training (e.g., instrumented live-fire trials, firing in special limited visibility conditions). Likewise, valuable data on the training programs for these tests provided the critical links between instructor behavior, training resources, and soldier performance.

Task difficulty is one of many factors that influence the training process and the corresponding training resources. Because the AAWS-M impact analysis showed similarities between some of the gunner tasks and skills required on both the Dragon and the AAWS-M, published reports of Army tests on the Dragon were reviewed to determine task/skill difficulty. The resources used to train soldiers for each test were also identified. In effect, the review constituted a secondary analysis of the data; test reports were considered vital historical documents.

Although each test had a unique purpose, it was assumed that, when considered collectively, the historical data on Dragon would provide information on most Dragon gunner tasks. Seventeen operational tests and additional analyses conducted from 1972 to 1986 were reviewed. The test results concentrated on hit probability and documented firing problems. More sophisticated instrumentation, such as thru-sight video, revealed even more detailed information on gunner performance during Dragon firing; this, in turn provided a better understanding of the nature of the firing task. A complete picture of task difficulty, however, was not provided. Gunner proficiency was assessed on only half the tasks. Some important subskills, such as the gunner's use of stadia lines and the sight picture to determine whether targets are engageable, were examined infrequently or not at all. With the exception of target detection, measures of both time and error data were not collected on individual tasks and skills.

Another assumption was that, given the emphasis on Dragon training and training devices in many of the tests, the program of instruction (POI) would provide insight into how an effective AAWS-M POI might be designed. The training information, however, was typically limited to a one or two-page outline of POI topics, plus the Dragon training device firing tables. No formal observations were made which documented all of the training resources.

The greatest detail regarding the training process was found in tests which examined the amount of time required on the Dragon training device.

To obtain specific information on AAWS-M training requirements, AAWS-M contractor training during proof-of-principle was observed, and training resources documented. These observations were extremely valuable in estimating final POI requirements. As expected during early stages of system development, however, the contractors designed their instruction to meet the needs of each test, and soldier training was conducted on prototypes. Thus, as with the Dragon tests, not all gunner tasks/skills were trained. Consequently, the impact of discrepancies between prototypes and the expected final designs upon skills acquisition, skill decay, and training resource requirements had to be estimated, as did the resources required for the tasks not trained.

It may be unrealistic to expect detailed information on training programs in system test reports. However, given the cost of many system tests and the unique data they provide, the inclusion of more information on soldier training in test reports would be extremely valuable to decisionmakers, for very little cost.

In instances where many and/or complex questions regarding training are unresolved, a formal comparison of alternative training programs may be advisable. Such situations include: determining how to use new training devices; comparing alternative instructional software on a device; determining training device standards; determining training effectiveness with specific soldier and instructor populations; examining possible interactions between soldier traits and training programs; and determining training resource proficiency trade-offs. It is generally easier to conduct research on training problems during system and training device development, when everyone is in the "experimentation mode," than after system fielding. Information on the training process gained during system tests can reduce the risk for decisionmakers by providing better estimates of training costs before system fielding.

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# HCI Abstracts:

## The First Abstracting Journal on Human-Computer Interaction

HCI Abstracts, the first abstracting journal devoted entirely to the literature in the area of human-computer interaction, will be published this summer by Ergosyst Associates, Inc.

Derived from the Human-Computer Interaction (HCI) Library Database at the Scottish HCI Centre in Glasgow, Scotland, HCI Abstracts is designed for departments and workgroups involved in HCI research and development, as well as corporate and academic libraries serving computer scientists, engineers, researchers, and designers concerned with any aspect of computer usability.

The scope of HCI Abstracts extends from computer systems and applications to embedded microprocessor technology involving computer-based interaction in non-computer systems. Abstracts cover books, journals, articles, reports, and conference proceedings in the English language from world-wide sources-- in short, research and application in all relevant areas.

Abstracts are organized into categories such as user interface design, design guidelines and standards, tools and methods, documentation and user training, software engineering, organizational and social factors, and such applications as MIS, office systems, computers-as-media, dedicated and embedded systems, and computer-based education and training.

The emphasis of this new international, quarterly journal is on timeliness and selectivity. Abstracts are being entered on the HCI Library Data base at the rate of 500 a month. The HCI Centre has issued a call for participation to help them develop this database into one that will ensure that human computer interaction is thoroughly covered. Send all suitable materials to Dr. J. T. Mayes, The Scottish HCI Centre, George House, 36 North Hanover Street, Glasgow G12AD, Scotland, UK.

HCI Abstracts (Volume I, Number 1) will be published this summer. ISSN 1042-0193. $267.00/ year. For more information, contact Ergosyst Associates, Inc., 910 Massachusetts Street, Suite 303, Lawrence, KS 66044. (913) 842-7334.

# Organizing for MANPRINT: Industry's First Task

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In the development of improved weapons systems and the training systems which support them, there are a limited number of options to pursue. Such systems consist of the hardware and software and the soldiers who interface with that equipment--to include both operators and maintainers. Improved system performance requires an improvement in at least one of these components.

Despite all the technological advances of the 20th century, we have been able to do little to alter the basic design of the soldier. Although today's American soldier is taller and heavier than his 15th century-counterparts, the basic design remains the same: Two legs, two hands, and ten fingers. Even with experimentation in genetic engineering, it is unlikely that tomorrow's soldier will be any different.

Although soldiers must be considered as constants in the equation describing systemperformance, it may be possible to extend their contribution by improving the human-machine interface. Regardless of whether we use technology to better performance through improvements in equipment design or in human-machine interfaces, it is the contractor who must make the design changes.

As R. Bruce McCommons pointed out in the May/June 1988 issue of the MANPRINT Bulletin, although the key to success for this program lies within the government, "...the bulk of MANPRINT activities will be done by contractors." Thus the government's problem centers on how to communicate its needs and concerns to the contractor to ensure that MANPRINT issues are addressed during equipment design and development.

During my MANPRINT training, I found that there were a number of students who believed that the best way to ensure consideration of MANPRINT issues was to require that contractors provide a number of reports identified on a Contract Deliverable Requirements List (CDRL). This impression was reinforced when I reviewed the June 1988 MANPRINT Primer: "Appendix E" lists over fifty authorized Data Item Descriptions which may be included as CDRL items in a contract. It has been my experience that increasing the requirements for reports will be less than effective in improving the design of weapons systems. When you ask for reports, you get reports. While they cost money, the return on investment remains small. In fact, when effort must be expended in reporting on what was done, it is subtracted from the effort expended on the task itself.

A second approach to achieving MANPRINT goals centers on a reorganization in which MANPRINT offices are created and supported with overhead funds to serve as watchdogs on the corporate design efforts. The Primer specifically states that it does not intend to "dictate how and where industry should integrate MANPRINT," but consider the impact of "Appendix A" on a competitive procurement: "Evaluation of offeror's proposed MANPRINT organization,level of effort, lines of authority, etc..."

In a proposal, embedded MANPRINT lines of authority and assignment of MANPRINT responsibilities to line managers does not have the impact of a dedicated, "boxed" MANPRINT manager. Most major contractors already have a technical staff with expertise in all six of the MANPRINT domains. If the Primer implies that contractors should create yet another level of management to integrate and coordinate their effort, the costs of weapons systems will increase without corresponding improvements in weapons system performance.

What, then, is the answer? How should the Army go about securing the cooperation of industry in designing and developing weapons systems which optimize total system performance by incorporating manpower, personnel, training, human factors, system safety, and health hazards considerations into the process? I believe that the design engineer is (and should be) responsible to see that the design meets all of the specification requirements. This is a legal requirement as well as a pragmatic truth. Corporations have devised comprehensive review processes to ensure that designs of their products meet not only the stated contractual specifications, but also the guidelines of a sound engineering practice. The key to incorporating MANPRINT considerations into weapon systems design is the insertion of proper MANPRINT requirements into the specifications and Statements of Work. Once this is done, the established engineering design system will be working for MANPRINT.

How should the Army accomplish this? The solution is simple: We must ensure that the specification places the burden of designing for the soldier squarely on the design engineer. Typically, this individual is the most highly skilled senior engineer working for the corporation. The design engineer has reached a position of seniority because of skills, expertise, experience, and motivation to produce a superior product. Our problem is to discover how we may take advantage of these abilities.

The solution to this problem lies concealed in another question: To what drummer does the design engineer march? That is, what motivates design engineers to incorporate customer requirements in their design and perform their jobs to the very best of their ability? Fortunately, we know that the design engineer works to create a product which economically meets the requirements of the specification and incorporates sound engineering design practices that ensure compliance with customer requirements. The solution to incorporating MANPRINT considerations into the weapons system design is to get them in the specification! The government needs to say precisely: "Here is what we want."

Prior to issuing a Request for Proposal ( RFP), the government must understand the requirements of the mission and the limitations of the available manpower pool. These must be communicated to the contractor, along with the request for a design and cost proposal which will meet the requirements. The hardest part of this task is to include human limitations in the system specification. For programs in which it is the contractor's responsibility to develop an acceptable systems specification, the government must include MANPRINT constraints in the original Statement of Need and in theTechnical Requirements document.

When the government asks for a system that can be operated by humans with 5th percentile strength, an eighth grade education, and with less than 40 hours of training; when it calls for a system which meets OSHA sound-level constraints for a planned eight-hour-per-day exposure; when it calls for a test program which will show a 90 percent success rate demonstrated by a group of 30 newly recruited soldiers performing 100 trials apiece without reportable accidents, then the design engineer will be able to understand what is needed. With human limitations clearly defined, he will see the requirement to seek out the expertise from each of the six MANPRINT domains to complete the design.

When this approach to implementing MANPRINT is followed, we can expect that the chief design engineer (or the Deputy Program Manager) will remain responsible for the system design, while the necessary system characteristics will be provided and integrated through a team effort. The requirement for additional reports is reduced, and the costs of nonproductive overhead for monitoring and inspecting are held to a minimum.

Will this approach work? I believe it will. It certainly makes good business sense for industry. However, it places a heavy burden on the military community: Statements of Need must be written to include an assessment of manpower and personnel constraints. Technical Requirements documents must spell out the nature of the operational environment and maintenance limitations. Anticipated ceilings on training, with budget and time factors, must be communicated to the contractor. The government must ensure that specifications are carefully written to call out MANPRINT concerns in the design and in the test and evaluation of new systems. Evaluators of industry proposals will have to look beneath the surface organization to gauge the level of a contractor's commitment to the spirit of MANPRINT. Finally, contract negotiators will have to be careful not to yield to pressure to cut costs by trading away the analyses and studies needed to ensure proper system design.

When this happens, both the government and industry will have taken a giant step as partners in the development of better systems. MANPRINT will be working to help design teams produce equipment that fits the soldiers who must use it. This transition will not be easy, but it will certainly be worthwhile.

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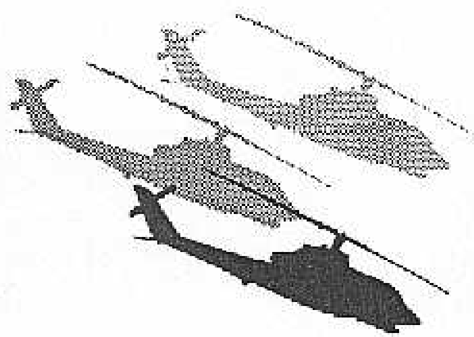
# Using Video for Empirically Validated Task Analysis (EVTA) of System/Human Interaction and Performance

Margaret T. Shaffer
Paradigm, Inc.

Activity sampling and time and motion studies, used since the 1950s, have received a recent resurgence with the widespread availability of video cassette recorders. Video provides a permanent comprehensive source document: It can be replayed until all data are observed and recorded, can be reviewed by different analysts, and is replicable over time. The analyst with the clipboard and the stopwatch now has a powerful tool that permits expanded analysis of complex behavior in settings previously closed to all but operational personnel. With the new miniature cameras and recorders, the analyst can be "present" in confined spaces and in hazardous areas. Information provided can be used for system design, the identification of training needs, workload analysis and performance evaluation.



Video analysis provides a unique opportunity for the evaluation of system/human interaction and resulting performance. Any measures of performance which are visible on the videotape or that can be tied to a time hack can be studied; in addition, antecedent behaviors which generate specific errors or performance levels can be evaluated. By using multiple videotapes (or multiplexed cameras), it is possible to integrate information from different crewmembers or sources (e.g., multi-function displays) into a single transcript to be analyzed together.

It was these features that led Paradigm, Inc., to explore the application of video analysis in a workload assessment in January, 1985. Most other methods have relied almost entirely upon subjective evaluation by subject matter experts who utilize a relative scale for their assessments. One difficulty with these approaches is that they are dependent upon the skills and biases of the rater.

The initial developmental video analysis work was performed under subcontract to IBM as a part of the LHX/ARTI (Light Helicopter Experimental/Advanced Rotocraft Technology Integration) program. This project aimed to determine whether the LHX could be piloted by one crewmember who would be responsible for flying the aircraft and operating all of the installed systems.

The new technique, called Empirically Validated Task Analysis (EVTA), involved the analysis of videotaped exercises in a predecessor system, the two-man OH-58D helicopter. These videotapes recorded internal and external communications, as well as cockpit activities. Analysis of simultaneous activities was also performed. Time and motion studies, as well as an evaluation of some cognitive processes that were evident from internal communications, were employed in the study.

The empirical data generated by the EVTA methodology provides an objective measure of the broad range of functions occurring when the crew is involved in actual mission activities. By identifying tasks which contribute greatly to the overall workload, it is possible to delineate those subsystems which could benefit most by engineering enhancements to reduce workload. The analysis identifies functional categories that should be considered for automation to reduce the workload for a single-pilot configured helicopter performing missions that are currently performed by two crewmembers.

Communicating these workload findings to the engineers who are responsible for designing aircraft systems has been a problem; much of the subjective data has been disregarded because it is perceived as "soft data." The data generated by the EVTA process is not only "hard" (e.g., frequencies, means and standard deviations of task time), it can also yield a "video report," or demonstration tape. A "demo" tape illustrating the findings and issues identified in the analysis, using actual footage, was produced on the IBM study. The tape illustrated the problems that were identified by the data, making it easy for the engineers to see what problems surfaced as a result of both environmental conditions and systems design. This demo tape is used in conjunction with presentation of the findings, as well as a discussion of the EVTA methodology.

Following the widespread acceptance of the data generated in this first study, Paradigm, Inc. set about to reduce some of the labor intensiveness inherent in applying the methodology. Because some type of computer software was needed to facilitate the input of the large amount of information usually generated by the process, Paradigm developed the EVTA Software program.

EVTA Software, which uses an IBM PC or compatible equipment and dBase III+, provides a time-based transcript of activities for individual crewmembers or for the crew as an integrated unit. The transcript shows start and stop times, the operator involved, and the system mode for all activities and communications, and serves not only as the basic data source for all subsequent steps in the EVTA process, but also as a mission scenario. Transcripts and all data tables are generated in camera-ready copy to facilitate the reporting process.

The software's Simultaneous Activity Analysis capability allows for the identification of all activities and communications which are performed simultaneously for a given crewmember. The program identifies the frequency of occurrence of each pair of tasks and computes three metrics of time: concurrent, occupied, and serial. In addition, unoccupied time may be computed.

The EVTA program computes descriptive statistics (mean, standard deviation, minimum and maximum) for task completion times, the proportion of mission time devoted to each task, and frequency of occurrence. Analyses can be performed separately by operator, mode and/or mission type.

Paradigm is working to further develop and refine the EVTA process and accompanying software. The EVTA process was recently applied to a study of low-level Army helicopter operations for the Canadian Department of National Defence as an input to the Canadian Forces Light Helicopter (CFLH) project. In this project, plans have been made for providing the detailed data tables generated by the EVTA process to all bidders for the development of the new CFLH. The EVTA methodology was further refined in a study for Patuxent River Naval Air Test Center, Maryland. In this effort, multiplexed video signals from cameras focused on each of the four crewmembers is presented on four monitors simultaneously and is being analyzed by the EVTA process. The multiplexer permits the simultaneous recording of four cameras on one VCR. In addition to focusing on the activities of the crewmembers, we are evaluating the time expended by the research team in each step of the EVTA process in an attempt to reduce the labor intensiveness of the process without reducing the effectiveness or validity of the data. In addition, Paradigm is looking at hardware for automating the entry of time data directly from the VCR into the data base in order to further reduce the time required for the analysis.

Although all of the developmental work on the EVTA methodology and Software has been performed for the military, Paradigm is "genericizing" the process so that it can be applied to academic, laboratory, industrial and office settings, or in any environment which can be videotaped and for which the cost of the analysis can be justified by substantial savings in design and development costs, training costs and/or operational error reduction.

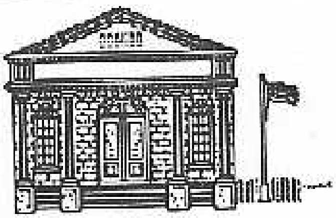
*For more information, contact: Margaret T. Shaffer, Paradigm, Inc., 8815 Quiet Stream Court, Potomac, MD 20854. (301) 299-7551/7555.*

## NOTABLE QUOTES

*"Ergonomic standards have been, are being, and will be misused because standards--by definition--imply the minimum requirement to perform the task, not the optimal. I would have liked to indicate a minimum acceptable standard and to have a desirable standard, so that below you really violate the rules. If you want to optimize performance and satisfaction, you should pick out the desirable level."*

Dr. Gavriel Salvendy,
Professor of Industrial Engineering,
Purdue University

** As quoted in Ergonomics Sourcebook, 1987*



## Schedule of Upcoming MANPRINT Courses

### MANPRINT Senior Training Course

24-28 July 89 (Ft. McClellan, AL)
21-25 Aug 89 (Warren, MI)
25-29 Sep 89 (Ft. Eustis, VA)

### MANPRINT Staff Officers Course*

7-25 Aug 89
11-29 Sep 89
16 Oct- 3 Nov 89
27 Nov-15 Dec 89

*All courses will be held at Ft. Belvoir, VA.

## MANPRINT INFORMATION

**POLICY** - MANPRINT Directorate, HQDA (DAPE-MR). Washington, DC 20310-0300. AV 225-9213, COM (202) 695-9213.

**MANPRINT TRAINING** - Soldier Support Center-National Capital Region, ATTN: ATNC-NM, 200 Stovall St., Alexandria, VA 22332-0400. AV 221-3706, COM (703) 325-3706.

**PROCUREMENT & ACQUISITION** - US Army Materiel Command, ATTN: AMCDE-PQ, 5001 Eisenhower Ave., Alexandria, VA 22333-0001. AV 284-5696, COM (202) 274-5696.

**HUMAN FACTORS ENGINEERING STANDARDS AND APPLICATIONS** - Human Engineering Laboratory - MICOM Detachment, ATTN: SLCHE-MI, Redstone Arsenal, AL 35898-7290. AV 746-2048, COM (205) 876-2048

**MANPOWER, PERSONNEL AND TRAINING RESEARCH** - Army Research Institute, ATTN: PERI-SM, Alexandria, VA 22333-5600. AV 284-9420, COM (202) 274-9420.


**16-20 October 1989**

**33rd Annual Meeting of the Human Factors Society.** Denver, CO. Contact: The Human Factors Society, Box 1369, Santa Monica, CA 90406. (213) 394-1811/9793.

**6-10 November 1989**

**31st Annual Conference of the Military Testing Association .** San Antonio,TX. Contact: USAFOMC (ATTN: MTA) Randolph AFB, TX 78150-5000. AV 487-6623 or COM (512) 652-6623.

**13-16 November 1989**

**Interservice/Industry Training Systems Conference: "Training Through Teamwork - Meeting the User's Needs."** Ft. Worth, TX. Sponsored by the American Defense Preparedness Association. Contact: Capt. Jackson or Ms. Amy Enwright, ADPA, TMAS, Rosslyn Center, 1700 N. Moore St. Arlington, VA 22209. (703) 522-1820.

## GENERAL INFORMATION

Proposed articles, comments, and suggestions are welcomed, and should be mailed to: <u>MANPRINT Bulletin</u>, ATTN: HQDA (DAPE-MR), Washington, DC 20310-0300. Telephone: AV 225-9213, COM (202) 695-9213.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