MANPRINT BULLETIN

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The MANPRINT Metric in Testing and Evaluation

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Editor's Note: The following is an edited version of an article that appeared in the September/October 1989 issue of the Army RD&A Bulletin.

Before discussing MANPRINT testing and evaluation, it is important to clarify some important aspects of the relationships among the six MANPRINT domains. Of these domains, human factors engineering is unique among them in that, while it clearly belongs with the others in any list of domains to be considered in integrating human requirements into system design, it is the only domain that offers a direct way to influence hardware design.

The system engineering requirements generated by the MANPRINT domains result in human engineering specifications as design inputs. In attaining the MANPRINT goal, considerations involving the MANPRINT domains either affect the requirements of some other MANPRINT domain or they affect system engineering via human engineering design of the system's hardware. Human engineering design is the only way in which they can affect anything other than the MANPRINT domains themselves. For example, if a given human task is not being performed quickly or accurately enough to support system performance requirements, the system design change required to correct the shortcoming can address either the human or the machine side of the human-machine interface.

If a hardware change is selected as the solution, we are dealing with a human engineering change. However, if the shortcoming is addressed via the human side of the interface, the change involves either the number or the characteristics of the people who perform the task, or their training, thus impacting on the manpower, personnel, or training requirements of the system.

Continued on page 2

VIEW FROM THE TOP

An Interview with the Army Chief of Staff

Our first issue of 1990 issue features an exclusive interview with the Chief of Staff of the Army, General Carl E. Vuono, found on page 6. Happy New Year!

Metric (continued from page 1)

The increased focus on the soldier-machine interface within the engineering design process, as emphasized by the MANPRINT program, is not a sudden change. (See Figure 1, found on page 3.) Instead, it has been a gradual one related to an emphasis on developing total systems, in contrast to developing separate hardware, training, software, logistic support, technical documentation, and facilities, and later combining them into an effective system. This metamorphasis is by no means complete. There are many members of the acquisition community who still say "system" when they really mean "hardware." The difference between the two concepts may seem somewhat superficial, but it has fundamental implications for the way in which the Army develops new combat systems. It also has some profound consequences for testing and evaluating developmental systems.

During development, the systems approach requires that many players enter the process at the beginning. The materiel developer, the combat developer, the trainer, the logistician, and several others must participate in defining goals, requirements, and limitations for the system.

Unlike the somewhat fragmented approach to development mentioned earlier, the systems approach requires that each player participate in a trade-off process. In this process, all participants make an attempt to arrive at a cost-effective means of acquiring a new combat capability. For example, a trade-off which might be negotiated is a choice between a hardware design that is high in acquisition costs but imposes human performance and skill requirements that are cheap to acquire and maintain, versus a hardware design that is lower in acquisition costs but requires human performance and skills that may be very costly to acquire and maintain. Based on the available cost predictions, the alternative that meets the system goals at the lowest life-cycle cost can be selected. *Now, what does all of this have to do with MANPRINT testing and evaluation?*

Once the focus of attention shifts from "materiel" to "system," the business of testing and evaluation becomes quite different. In component-level, and even in subsystem-level testing, hardware functions are exercised in a way in which any human function is assumed to have a probability of being correctly performed the first time and every time. The concern in this type of testing is nothing more than "Did the hardware work as expected?" The assumption is explicit that failures due to human error are not chargeable to the hardware design. An implicit (and probably wrong) assumption here is that the manpower, personnel, and training resources available when the system is fielded will be capable of meeting whatever human performance requirements have been built into the hardware.

Testing and evaluation under a systems approach acknowledges the influence of the operator and his or her performance on total system effectiveness and reliability. Soldier-in-the-loop testing attempts to exercise the system using a sample of soldiers, who, by aptitude, training, experience, and physical characteristics, are typical of the average user. An attempt is made to control the variation in the soldier sample by using selection criteria, or at least to account for it with demographic data. Within available test resources, system functions are exercised over a representative sample of the conditions (terrain, weather, visibility, and others) that are anticipated when using the system in training and in combat.

In the interest of efficiency, human performance testing is often conducted as a part of testing for other aspects of the system's performance. Whether MANPRINT data are collected in a separate test or during testing of some other aspect of performance, there are basically three kinds of information that will be collected. These are engineering measurements, user opinion, and human performance data.

Engineering Measurements

When planning for MANPRINT testing and evaluation, engineering measurement is usually considered first. In establishing the system's goals, requirements, and limitations, applicable military standards and specifications should be cited by the government as design standards to be met. Requirements documents may also specify military handbooks and other sources of guidance for use in hardware design. In general, engineering measurements are used to evaluate compliance with these requirements. The required data, which are often collected without the participation of the system's human component, may address requirements in such areas as: size, weight, lighting level, noise level, crew workspace layout, ingress and egress

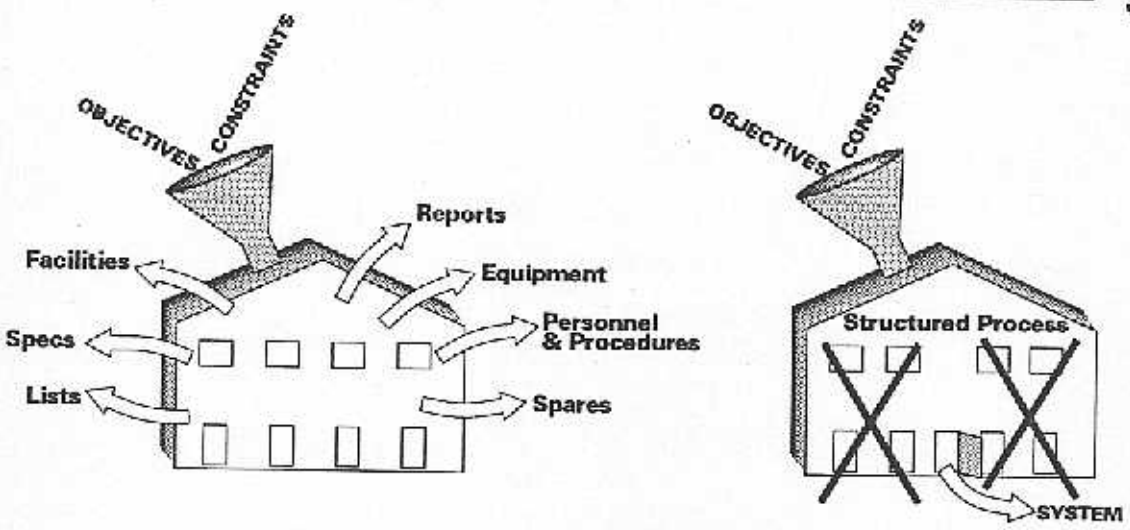


Figure 1. The Traditional Approach vs. The Systems Approach

provisions; and temperature, vibration, and display brightness.

User Opinion

This second category of information is gathered from test participants, test control personnel, and observers. This information is used to learn about those system characteristics that might not be revealed by engineering measurements.

Troops generally will not function at optimum effectiveness with equipment they dislike or mistrust. Obviously, the most direct way to find out how a user feels about equipment is to ask his opinion. User insight may suggest improvements in hardware design or in operating procedures that compliance checking would not reveal.

Problems reported by users may also identify system characteristics that point to health hazards or to system safety problems. It is important when using such information, however, not to fall into the trap of accepting subjective user opinion regarding system performance as a substitute for objective performance measurement. In addition, do not assume that system characteristics which the users dislike necessarily translate into degraded soldier-machine system performance.

Human Performance Data

The remaining task involves exercising mission-critical tasks to collect and analyze task performance data. Data collection must be based on a review of the human performance requirements associated with the system. If the performance requirements have been properly specified in the requirements documents and a usable task analysis is available, a good start has already been made on identifying tasks on which to collect human performance data.

Other inputs to the task selection process should include technical manuals and training materials used in training test participants. The list of selected tasks should have as its highest priority those tasks whose performance defines an outer limit on total system performance (e.g., in a tank system—loading, laying, and firing the gun).

Human performance time and error rate are the two basic measurements used in human performance testing. For each task exercised and measured in the test, both kinds of data must be collected. Both measures are critical because, for most tasks, performance time and error rate can be traded off one for the other. The priorities with which the test participant approaches any task can radically affect whether he emphasizes speed of performance at the expense of accuracy or conversely, accuracy at the expense of speed. For some tasks, the trade-off function itself may be more important than either data point alone in affecting both design changes and operational doctrine for the system.

Continued on page 4

Metric (continued from page 3)

Data analysis should first compare achieved performance against the goals established in the system requirements documents. If the system's front-end analyses have been thorough enough to define criteria for task performance, then they will also define the test criteria.

For those systems without stated criteria, the performance data are used to predict what the performance in the field will be. The question of "How good is good enough?" then gets a post hoc answer, but at least the decision of whether to accept a system will be an informed one, based on knowledge about currently achieved performance.

Another use for these data is identifying areas in which human engineering design improvements have a high potential pay-off in terms of reducing "people costs" or improving the system's performance. If, for example, the data show an unexpectedly long performance time for one of a series of sequentially-performed tasks, then that task would be identified as a priority candidate for improvement in the hardware associated with it or the procedures for performing it.

Consideration might also be given to machine-aiding or automating part or all of the task's performance. The costs of these alternatives would be compared to the costs associated with attempting to improve task performance by setting higher soldier selection criteria or by investing in more training on that task.

MANPRINT Evaluation

The bottom line for the MANPRINT evaluation of a soldier-machine system is reached when the evaluator answers the question "So what?" for each test issue. The specifications and standards against which we evaluate engineering measurements should be met. Their criteria have been developed from experience with many past systems, and meeting those criteria improves the probability of acquiring an effective and efficient soldier-machine system. However, meeting those requirements does not by itself ensure that this has been achieved, nor does failure to meet one or more of the criteria guarantee an unsuccessful system.

Likewise, the user's feelings and attitudes toward the system are important. The Army has demonstrated too many times that a system that is not liked or trusted by the users has little chance of operational success. We must remember, however, that there is not a one-to-one correspondence between equipment characteristics about which users complain and equipment characteristics that can be shown to degrade their performance or total system performance. In competitive testing, soldiers often state a preference for an equipment design with which their performance is worse than with a less-liked competitor. There is a lesson we must acknowledge from this reversal: Test participants will readily express their feelings about how well they like a system, and are seldom reluctant to evaluate their and the system's performance; however, those feelings and attitudes, no matter how precisely and accurately we might measure them, have shown no consistent relationship to objectively measured performance.

The indications from engineering measurements and from user input are important in system evaluation to influence the selection of tasks for human performance testing. Obviously, if an equipment characteristic clearly violates a human engineering standard or if users feel that it significantly degrades their performance, then that characteristic merits closer examination. But the system, the human factors profession and technical area, and the MANPRINT program are all done a disservice when we attempt to evaluate system performance or human performance as one of its components without objectively measuring that performance.

The risk to the system is simply that our evaluation may be wrong, and we end up "fixing something that isn't broken." We might also accept a system with

Updated MANPRINT POC List

The *MANPRINT Points of Contact* (POC) list will be ready for distribution in January, 1990. POCs are asked to check the new publication for accuracy. Please report any changes--additions, or deletions--to Ms. Kristy Underwood, Automation Research Systems, Ltd., 4501 Ford Ave., 11th Floor, Alexandria, VA 22302; or telephone (703) 820-9000; or FAX (703) 671-3562.

design errors that reduce system performance without our even knowing that performance has been compromised. The long-term damage to MANPRINT or to any other program that attempts to integrate "people considerations" into system development may be much more significant.

We are continually challenged to document the value of human engineering and related disciplines to system design. When we justify decisions to change (or not to change) a system's design based on a prediction of performance consequences, and then base those predictions on anything less than hard performance data, both our credibility and future acceptance of MANPRINT inputs are jeopardized.

Put a bit more colloquially, if we want to know whether the materiel design has complied with the system specification and with applicable criteria in the standards, engineering measurements are appropriate; if we want to know whether the user likes it, user opinion is appropriate; but if we want to know how well the humans in the system perform, and how their performance relates to total system performance, there is no defensible substitute for human-performance measurement. That, I submit, is as close we can get to having a MANPRINT metric.

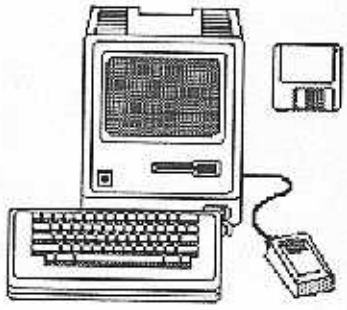
For more information, contact Dr. Jim Geddie, HEL Field Office-HQ TEXCOM, SLCHE-FH, Ft. Hood, TX 76544-5065; AV 738-9917 or COM (817) 288-9917.

QUANTITATIVE ANALYSIS IN A FLASH...

Rapid Automated Methodology - Diagnostic Tool (RAM-DT)

Michael G. Hart
Automation Research Systems, Limited

The Rapid Automated Methodology - Diagnostic Tool (RAM-DT) model, recently developed by Automation Research Systems, Limited (ARS), capitalizes on the Macintosh computer's powerful and intuitive user interface. RAM-DT uses a unique database structure needing a small fraction of the space normally required for the analysis of an entire weapon system. It also performs the analysis and generates reports in real time. This eliminates the normal "overnight update in batch, then generate reports" cycle that is associated with other systems.



The speed and flexibility afforded by RAM-DT for determining the quantitative manpower, personnel, and training (MPT) data required for a MANPRINT analysis is unprecedented. This tool can assist the development process and provide meaningful information all at once, rather than as an afterthought. Other quantitative analysis systems are limited by developmental time constraints to merely documenting MPT impacts. By using a unique hierarchical database structure, the RAM-DT analyst can quickly generate reports at any level of assembly indenture, or for ranges of tasks or maintainers. By merging all of the information associated with a quantitative analysis into a single record for each task, the user can view customized reports for any grouping of information desired.

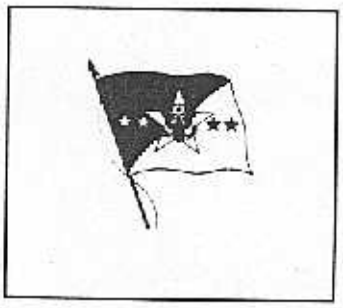
For the manufacturer tasked to provide meaningful MANPRINT information, or the government MANPRINT manager trying to make sense of an emerging weapon system, RAM-DT is a powerful tool for making complex tasks simple to perform. RAM-DT offers the power of a mainframe analysis package such as the Statistical Analysis System (SAS), but does so without the user needing years of programming experience just to print a report. **Real data made real simple: RAM-DT.**

For more information, contact John Whitehead, Automation Research Systems, Ltd., 4501 Ford Avenue, 11th Floor, Alexandria, VA 22302. (703) 820-9000.

VIEW FROM THE TOP

An Interview with GEN Carl E. Vuono, Chief of Staff, U.S. Army

General Vuono, it seems appropriate to close out the fiscal year with your thoughts on MANPRINT—the Army program designed to equip the man rather than man the equipment. Just what does the Army mean by the term "equip the man?"



"Equipping the man" is a term we use to describe how the Army wants its hardware and software systems designed. Weapons and other types of Army equipment must be designed with the soldier in mind. In the past, we have sometimes designed equipment without giving due consideration to the ultimate user—the soldier in the field. Our outstanding young soldiers and noncommissioned officers deserve better—for they are the basis for the trained and ready Army of today, and they are the foundation upon which the Army of tomorrow will be built. We have a sacred obligation to provide our soldiers with the weapons and equipment they need to achieve victory and to survive on the battlefield. This is the ultimate rationale that underlies the phrase "equip the man."

Why is there such renewed emphasis on soldier performance in this age of high tech solutions? Why hasn't modern technology made the soldier's job less difficult?

High technology offers us tremendous potential for the future. But this potential can be realized only if technology is properly harnessed. The Army's strategic requirements are growing more complex and demanding as we enter the decade of the 90s, and each soldier, unit, and leader must be able to execute multiple tasks. This is the essence of versatility, one of the Army's fundamental qualities necessary for the security of a nation in the years ahead. MANPRINT is an important tool in ensuring that high technology is effectively channeled to enhance versatility and to meet the challenges of tomorrow.

The practice of applying MANPRINT to the materiel acquisition process, has, from all appearances, gained far-reaching acceptance. Has the Army provided the resources necessary to ensure that MANPRINT is institutionalized throughout the defense community?

One of the tremendous advantages of MANPRINT is that it does not require a great deal of additional resources; the component parts of MANPRINT are already in place. What MANPRINT does is require the integration of these parts into a comprehensive program that meets the Army's needs. As a result, very few new resources are required to make MANPRINT work. The commands that are primarily responsible for the Army's combat and materiel developments have successfully budgeted the resource necessary to satisfy virtually all of the MANPRINT requirements.

During his tenure as Army Undersecretary, Mr. Stone (Michael P. W. Stone, Secretary of the Army) issued a directive mandating the evaluation of MANPRINT during the source selection process. How has industry responded to the requirement to address MANPRINT in its proposals?

The Secretary's memorandum was a major step forward in the MANPRINT program, and industry has reacted very favorably. Recent proposals from Army contractors have contained a host of solutions to potential soldier-related design problems. That is exactly what we wanted from industry in response to MANPRINT requirements—proposals that will enhance the Army's warfighting capabilities by focusing on the soldier.

Do the Army's program managers fully support the requirement to apply MANPRINT to their programs?

Contained in every program manager's charter is the MANPRINT requirement, and they are applying MANPRINT principles with growing effectiveness.

MANPRINT impacts on all dimensions of the programs for which PMs are responsible—cost, production schedule, and equipment performance. MANPRINT can affect costs by ensuring that the equipment we field is designed to be reliable and maintainable, even under highly stressful conditions. This, in turn, means that the equipment requires fewer support personnel, fewer spare parts, and a lower repair cost. Schedules are influenced by MANPRINT's early identification of problem areas that, if left undetected, could cause significant delays in fielding. Finally, and most importantly, MANPRINT helps ensure that the equipment, when fielded, performs to standard. This is accomplished by designing equipment around the soldier—the final arbiter of equipment performance.

How would you respond to the statement, "No one ever got fired for failing to do MANPRINT." Is that a fair assessment of the premium the Army places on the MANPRINT requirement?

The Army places a high premium on MANPRINT as design principles that will help shape the Army of the future. Evidence of our commitment to MANPRINT is found not only in the regulations governing the acquisition process but, more importantly, in the practical applications of MANPRINT throughout the Army. MANPRINT is still a relatively new initiative, so it will take some time before it is completely adopted in all reaches of the acquisition community. But the Army's commitment is unambiguous and, ultimately, MANPRINT will take its place as one of the pillars of Army acquisition.

How is MANPRINT being enforced? What would be your response if a major weapon program were halted because of unresolved MANPRINT issues?

MANPRINT considerations are introduced very early in the life of every program. MANPRINT issues that are raised are usually resolved without causing major delays in the program itself. If an issue cannot be easily resolved, however, it is brought before a full Army Systems Acquisition Review Council for consideration. In at least one instance, a major program was halted due to MANPRINT concerns, and this is as it should be. Remember that the overarching purpose of MANPRINT is to put effective equipment in the hands of our soldiers. If an equipment design is flawed to the extent that it will not be of value to the soldier, then we must reexamine the program and make the changes required. The old idea of fixing a problem later no longer works. We must detect and correct MANPRINT problems early.

What, if any, indications are there that MANPRINT is having the desired effect on weapons programs?

The T-800 engine program is an excellent example. Only ten tools are required to maintain that engine at the organizational level. That was no accident. The team that built the T-800 took the time to get to know the users, and their capabilities and limitations, before designing the engine. That's MANPRINT at work. The LHX [Light Helicopter Experimental]— a program of great significance to the Army and to the nation—is another example. There are two teams competing for the contract, and both are making unprecedented efforts to ensure that the LHX will successfully accomplish its battlefield mission when placed in the hands of our soldiers.

The high-visibility programs, such as the Heavy Force Modernization (HFM), LHX, and AAWS-M (Advanced Anti-tank Weapon System-Medium), are receiving a great deal of MANPRINT scrutiny and support. But these high-dollar programs are not the norm. How does the Army ensure that some degree of MANPRINT is being applied to the hundreds of non-major programs?

Our guidance on that point is clear: No program, project, or product—whatever its size or cost—is exempt from MANPRINT review. Because of its basic design, MANPRINT is easily tailored to the size and needs of each individual program, and if necessary, the Army can provide additional oversight and direction.

General Vuono, I want to thank you for submitting to this interview. Is there anything else about MANPRINT that you would like to share with our readers?

First, I would like to thank the editors of the *MANPRINT Bulletin* for giving me the opportunity to discuss MANPRINT. Because MANPRINT, above all else, is a program for soldiers—the quality men and women who make up the Total Army family. We are today a trained and ready Army because of the soldiers that make up our ranks—soldiers that de-

Continued on page 8

Vuono Interview (continued from page 7)

serve the finest equipment that our nation can produce. I urge all those associated with MANPRINT to maintain your "soldier first" orientation, and I congratulate you on all that you have accomplished with this far-reaching and important program. In the future, there will be soldiers that will survive, and victories that will be won, because of what you are doing today.

GEN Wagner Speaks Out on MANPRINT

Editor's Note: The following is an excerpt from an interview with GEN Louis C. Wagner (AMC commander until his retirement in September, 1989) that appeared in the October 30, 1989 issue of Army Times.

The MANPRINT program was introduced into the materiel development business a few years ago. Are industry, AMC, and the Army personnel community satisfied with this process now?

I believe we are. I think it is embedded in the process now. I know that with the programs I have been involved with in source selection, it has been given a very high priority. I know that when source selection boards are put together, they include, in very high positions, users [of the equipment] to be absolutely sure that the MANPRINT aspects of the equipment are considered.

On the other hand, it is never something we can let down on. Because the minute we let down, I am afraid the same thing will happen that did in the past --if we have to make a trade-off because of dollars, they'll trade off things that make it easier for the soldier to operate and look for higher performance. We can just not allow that to happen.

I was told, incidentally, by some people in industry...that industry believes when GEN Maxwell Thurman [former TRADOC commander] and I leave, MANPRINT will die. I don't think that's true. It is well documented now in the regulations and in the guidance for program executive officers and project managers. I can assure you it is high on the priorities of the major subordinate commands of AMC and the center commanders in TRADOC.

? Did You Know?

• The Human Factors Society has recently published the first edition of its *Directory of Human Factors/ Ergonomics Consultants*. This publication contains the names of 113 individuals and nine companies that offer consulting services in the field of human factors/ergonomics.

Among the areas of specialization mentioned by the individuals and company contacts are forensics, computer systems, workstation design, training, safety, product safety/design, human performance, and transportation systems. Listings contain such information as name and address, educational background, supplemental background information, and a description of consulting expertise/experience. The directory may be purchased from the Human Factors Society at the postpaid member price of $20.00 or the nonmember price of $35.00. For more information or to order, contact The Human Factors Society, P.O. Box 1369, Santa Monica, CA 90406; (213) 394-1811/9793 or FAX (213) 394-2410.

• The *Proceedings of the Human Factors Society 33rd Annual Meeting* is now available. The two-volume publication contains articles and abstracts of papers presented at the meeting held October 16-20, 1989 in Denver, CO. The price is $45 for Human Factors Society members, and $60 for nonmembers. For more information, or to order, contact the Human Factors Society at the address listed above.

• The ODCSPER MANPRINT Office is sponsoring a MANPRINT/Industry Seminar to be held in March 20, 1990 in Alexandria, Virginia. Abstracts for presentations are being solicited from invitees. Watch for a report on the seminar in an upcoming issue.

MANPRINT Positions Available

Operational Test and Evaluation Agency (OTEA) has Engineering Psychologist positions available (GS-13) which involve planning, analyzing, and reporting MANPRINT aspects of operational testing. Contact Camilla Allen (Fort Myer CPO, 696-3180) for application materials under announcement M-830-89 (CA).

Design Support Systems Directory Currently Being Developed

Sue Bogner
U.S. Army Research Institute

The Human Factors Engineering Technical Group's Designing for User Subgroup is developing the *Annotated Directory of Design Support Systems* to provide a resource for people who design or evaluate new equipment and systems. Included will be information on databases and knowledge bases (handbooks, textbooks, journals, standards and specifications); tools and technologies (prototyping and interface design tools, analytical techniques, simulation software, and computer-aided design/manufacturing/engineering tools); and experts who can provide design advice.

A format has been developed for use in describing each entry for the Directory, as shown in the box on this page. The format allows a brief (maximum two pages) description of the characteristics, uses, state of development, equipment, and input and output of the design system. Strict adherence to the format will minimize editorial changes and allow maximum convenience for the Directory user.

If you would like to have your Design Support System included in the Directory, mail the formatted system description to:

Marion P. Kibbe
Code 3152, Human Factors Naval Weapon Center
China Lake, CA 93555

or

Sue Bogner
PERI-SZM, U.S. Army Research Institute
5001 Eisenhower Ave.,
Alexandria, VA 22333-5600

Plans also include putting the Directory into the Defense Technical Information Center (DTIC) data base and distributing copies of the Directory at the Technical Group Meeting to be held in the Spring.

Further information may be obtained by contacting LTC Rudy Laine, MANPRINT Directorate, HQDA (DAPE-MR), Washington, DC 20310-0300; AV 225-9213, or COM (202) 695-9213.

Design Support Systems (DSS) Format

Overall Classification:

State of Development:

Name of Design Support System:

1. Ownership:
2. Point of Contact:
3. Phone Number:
4. Description:
   a. General Overview of DSS:
   b. Appropriate Uses:
   c. Equipment Required for Use:
   d. Inputs Required for Use:
   e. Processing Techniques for Input:
   f. Output Consists of:
   g. Use of Output:
5. References:
6. Alternative or Comparable Approaches:
7. Stage of Development of the Method:
8. How To Obtain the DSS: (Name, Organization, Address).
9. Comments: