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MICRO SAINT

A TOOL FOR HUMAN FACTORS ANALYSIS

by Lori Hood and Susan Dahl,
Micro Analysis and Design, Inc.

In order for a system to incorporate human factors concerns effectively, manpower, personnel, and training (MPT) considerations must be integrated into the design of that system. To successfully meet this integration challenge, the design process must be approached with a different emphasis than ever before. Designers must ask the question: *Can a specific operator or maintainer, with specific amounts and types of training, perform the tasks I am designing, to acceptable standards, under realistic conditions, using this equipment?*

In order to answer this question, we must first be able to quantify and specify each part of the MPT equation. *Micro Saint*, a stochastic network simulation tool, is being used in a number of different areas of MANPRINT to address such issues as personnel quality, training, requirements specification, mission specification, and performance requirements of the system, where the system includes the hardware, the operator, and the maintainer. Many of the tools developed specifically to support the MANPRINT Program are customized *Micro Saint* models. These tools include the System Performance and RAM Criteria Development Aid (SPARC), Manpower Capabilities Analysis Aid (MANCAP), Manpower-Based System Evaluation Aid (MAN-SEVAL), and Personnel-Based System Evaluation Aid (PER-SEVAL). *Micro Saint* has proven to be a valuable tool for the analysis of MANPRINT issues. *Micro Saint* models can be used to perform trade-off analysis, thereby ensuring that the human element in the system is considered over the system's life cycle.

The purpose of this article is to provide an introduction to the modeling concepts and features of *Micro Saint* simulation software.

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Methodology

Micro Saint was developed in 1985 specifically for modeling human performance in complex systems. One of the biggest challenges in the original development project was to provide a powerful and flexible tool that could be used by psychologists and human factors engineers. This target audience tends to have a limited exposure to both simulation and computer science. This meant that the modeling approach had to be different from other simulation products available at the time. The engineers at Micro Analysis and Design, Inc. chose to develop *Micro Saint* by using a methodology known as *task network modeling*. Task network modeling represents activities in a diagram as nodes, and the arrows between the nodes represent the sequence in which the activities are performed. A simple task network is shown in Figure 1.

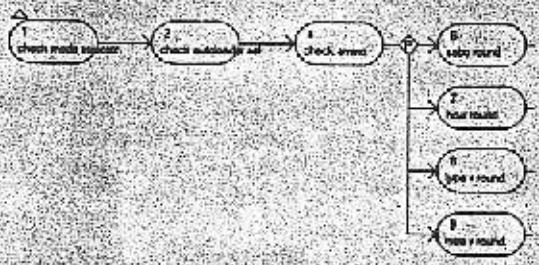

Figure 1. Sample Network Diagram

This approach allows users to develop models using the same techniques that they would use to define a flow diagram of the activity. Each activity, whether it be a human activity or a system activity, is defined using the same method. This minimizes the complexity of the user interface and eliminates the need for programming blocks within the simulation.

A *Micro Saint* model is composed of networks which may be a sequence of tasks to be performed by a human or a series of processes that define the behavior of a system, (i.e., threats in the environment, a helicopter, a computer interface). Networks are composed of either additional lower-level networks or tasks. Although the identifier task has connotations of human activity, it is not restricted to such. Tasks represent the lowest level in the model and have specific parameters (timing information, conditions for execution, beginning and ending effects). The following section explains the task parameters in more detail.

Task Timing Information

The task mean time is the average time that a task takes to complete once it has begun executing. For example, if the task represents a human activity such as "engage target," then the mean time to execute this task is the average time that it takes to perform the task. In many cases, the execution time is not constant. Rather, the elapsed time falls within a range of values that can be represented by a time distribution. *Micro Saint* supports more than 14 distribution types including normal, rectangular, exponential, gamma, wiebull, poisson, and others. In addition, users may enter parameters that control the spread of the distribution.

Alternatively, the mean time may be determined by the current state of the system or by an attribute of the process itself. In human performance modeling, the mean time to perform a task may be influenced by such conditions as how long the human has been working, the skill level of the human, or the current workload.

Conditions for Execution

Often there are situations where a task cannot begin executing until certain conditions are met. A maintenance task cannot be performed until a technician with the appropriate skill level is available. A task may have resource requirements or other constraints (i.e., time of day, tool availability) that dictate when the task may begin executing. In *Micro Saint*, users enter a Boolean (logical) expression in the "release condition" field to control the execution of tasks. The release condition expression may be as simple as "technician <> 0", or it may be a complicated expression where several conditions are evaluated such as, "(clock > 8 & clock < 16) & (operator <> busy)." Entities moving through the network, whether they be individual crew members, parts, or messages cannot be released into a task for processing until the *release condition* for the task evaluates to "true" (i.e., meets all criteria to move to the next step in the process).

Beginning/Ending Effects

The current state of the system may change when a task begins or ends. For example, when a maintenance technician begins repairing an engine he/she becomes "busy" and is not available to perform another maintenance task until the first task is finished.

The relationship between the release condition and the beginning and ending effects provides a general, yet powerful mechanism for users to define complex behaviors within the system they are modeling. Users may define variables that are specific to their system and manipulate the value of the variables as needed so that they can accurately represent their system.

A feature that greatly increases *Micro Saint*'s power is the parser that evaluates algebraic expressions. It provides the mathematical power of computer programming languages such as FORTRAN or C, but eliminates the need for compiling the model before running it. One of the biggest advantages of the parser is that it allows users to interactively change the value of model parameters while the model is executing. For example, the user could increase the number of resources available or change the execution time for a task while the model is executing to see what the overall effects on the system would be.

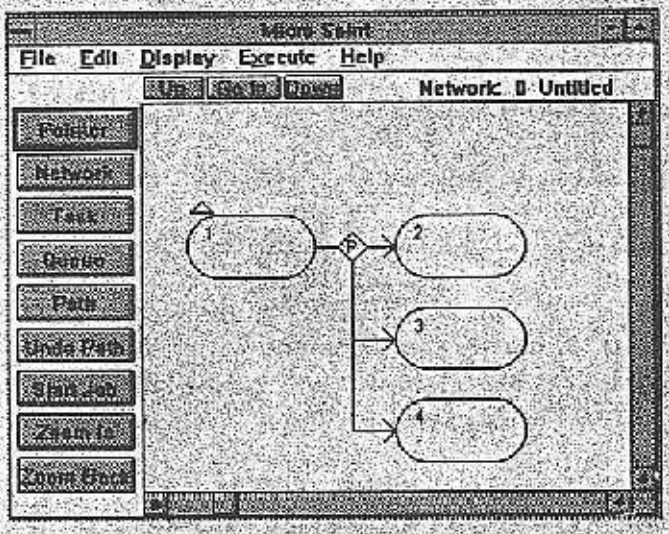

Figure 2. Micro Saint Tool Palette

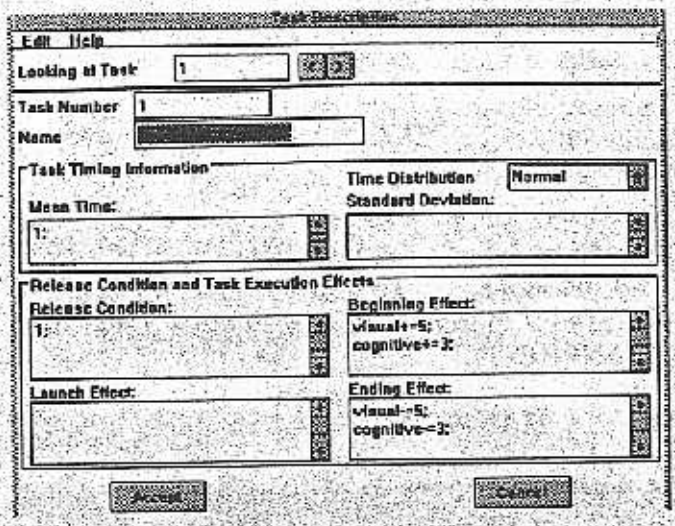

Figure 3. Micro Saint Task Description Window

Model Development

The process of building a *Micro Saint* model involves two separate but interrelated steps. First, the user must define the structure of the task network. This is done by selecting the appropriate tool from the tool palette and placing the object in the drawing space of the network diagram. The *Micro Saint* tool palette and drawing space is presented in Figure 2.

Micro Saint uses a standard Microsoft Windows® "point and click" approach to define the network objects. Using the mouse to "double-click" on an object will open it so that information specific to the object may be entered. Figure 3 is an example of the task description window that is opened when the user double-clicks on a task (i.e., node in the network).

Task sequencing is defined by clicking and dragging with the mouse from the first task to the following task(s). A diamond shaped decision icon appears on the network diagram when more than one following task is defined. Users must enter the conditions that control the branching when there is more than one following task. *Micro Saint* provides the following decision types to ensure that all real-world situations may be represented in the model:

Probabilistic: The following task conditions are evaluated and the next task to execute

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PUTTING MANPRINT IN TACOM

by Robert L. Swint and Phillip Cardon

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The need for modernized weapon systems can only be satisfied by modernizing our institutions and instruments. This fact is most apparent in the area of manpower and personnel integration (MANPRINT).

What is MANPRINT? If you randomly selected 15 people and gave them the opportunity to define MANPRINT, you probably would get 15 variations. However, let us attempt to describe MANPRINT using an example.

In 1959, Henry Kremer, a millionaire in the plastics industry, posted a prize for the first man-powered aircraft that could take-off and fly around a 1-mile, figure-eight course. Over the next 18 years, a number of people sought the prize. It was finally won in 1977 by a team that designed and flew the *Gossamer Condor*. The aircraft was literally designed around the man who would fly it. Refinements in the aircraft's design produced a model that man could fly across the English Channel 2 years later.

Throughout history, dreamers have had the will, whether consciously or not, to use MANPRINT principles; but the means to employ those principles are only recently being realized. We have adequate means today to achieve MANPRINT program objectives. The real question is: Do the Army and industry have the will?

The Army Tank-Automotive Command (TACOM) and the program executive offices have that will. TACOM systems will be designed to be compatible with the physical, mental, and emotional characteristics of the target user—the soldier. There should be no confusion about TACOM's commitment!

MANPRINT Organizational Structuring

This area is extremely important. MANPRINT will succeed only through willing, dedicated, and qualified people working in a conducive and receptive environment.

At TACOM, the focal point for managing MANPRINT is the integrated logistics support (ILS) function of the Readiness Directorate. The directorate's mission is to ensure compliance with higher-level policy and procedural requirements and to develop and maintain local policies and procedures in concert with other TACOM elements that have MANPRINT staff responsibilities. These elements are the Directorate for Maintenance, the Safety Office, and a local detachment of the Army Research Laboratory Human Research Engineering Directorate. Collectively, these organizations constitute a MANPRINT process improvement team that reviews local institutional processes for opportunities to increase effectiveness and efficiency.

The assignments of ILS as the focal point for the MANPRINT staff management should not be perceived as though TACOM equates MANPRINT with ILS, nor that MANPRINT is a subset of ILS. Existing mission and function allocations and the relationships between TACOM elements allow us to effectively institutionalize MANPRINT using this approach and to avoid the creation of a MANPRINT organizational "stovepipe." Realization of the full potential of MANPRINT is dependent upon the ability to cross organizational boundaries.

In program executive offices, the responsibility for managing MANPRINT is delegated to the program management (PM) organization. Although there is no policy assigning the MANPRINT function within the PM organization, the ILS organization generally provides both ILS and MANPRINT management direction. A matrix management structure provides technical expertise through specialty areas and offices that are internal and external to TACOM.

Government and industry clearly need a plan and an organization to manage MANPRINT, and neither should dictate how business should be accomplished. However, there must be adequate visibility and control of MANPRINT plans and execution of those plans at all corporate levels.

People working in a conducive environment will make the largest contribution to achieving MANPRINT program objectives. When each designer, quality assurance specialist, MANPRINT manager, and logistician perceives MANPRINT as a principal, critical element of his job, MANPRINT will be effectively institutionalized. This is our goal at TACOM and in the program executive offices. While we take pride in our accomplishments to date, it is clear that we still have considerable challenges to face. It is necessary to be steadfast in implementing MANPRINT policy and continually improving the associated processes.

MANPRINT Implementation Policy

One key policy is the insistence that MANPRINT be a principal evaluation element in the source selection process. Currently, it is not unusual to find definitive MANPRINT weights from 15 to 30 percent during source selection. However, its overall real weight is often greater when one considers the effects that MANPRINT considerations on subsystem and component design ultimately have on the technical-area weight. As we expand our experience with proposal evaluation and MANPRINT performance, we are becoming more discriminating. That is to say, the spread between the points awarded on an outstanding MANPRINT proposal and one that meets the status quo is increasing. This tendency is making it more difficult to offset MANPRINT deficiencies with slight advantages in other areas, such as technical and cost.

A second key policy, which is critical, requires MANPRINT to be clearly and comprehensively addressed in all specifications. We are conscious of the line that separates a design solution from the specified function or performance objective. We do recognize that for our industry partners to develop the best possible design solutions for soldier-to-machine interface, we must effectively describe the soldier, the anticipated environment, and the battlefield functions and performance requirements.

This brings us to the third key policy—conformance to specification. Herein lies the most significant challenge to the Government and industry. MANPRINT requirements must be successfully tested and evaluated in acquisition programs.

Tools for Achieving MANPRINT Objectives

MANPRINT test and evaluation objectives are twofold. The first is to ensure effective MANPRINT design through progressive improvements that are based on subsystem tests, modeling, and simulations. The second objective is to verify achievement of total system performance. Today, we are strong in verifying system performance in an operational environment; but we need to expand our abilities in the use of computer modeling, simulation, technology demonstrators, and effective design evaluation techniques using computer-aided design and engineering (CAD/CAE) during early system development. CAD/CAE systems provide user juries with the ability to evaluate MANPRINT issues and test specification requirements before prototypes are developed.

Efforts at TACOM in the area of computer modeling, simulation, and technology demonstrators have produced some advances, and industry is expanding these capabilities through a variety of forums, such as the independent research and development program. TACOM's newly established vehicle electronics (VETRONICS) laboratory has a crew display demonstrator. This device consists of a structure that provides for the installation of displays and crew controls in a variety of configurations and orientations. This demonstrator enables us to evaluate crew and crew-station interaction before a full system prototype is available. We have also installed a six-degree-of-freedom crew-station/turret-motion base simulator. This facility will lead to improved weapon system design and reduce the negative effect of vehicle motion and weapon-station motion on crew performance.

Finally, our VETRONICS laboratory is pursuing an especially noteworthy design initiative that will have a significant, positive MANPRINT impact. That is the adoption of a state-of-the-art standard Army vehicle electronics architecture. This initiative will bring ground-combat systems a large measure of hardware and software com-

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is determined by the relative probabilities of all tasks listed. Probabilistic decisions allow only one of the following tasks to execute.

Multiple: The following task conditions are evaluated and all of the tasks whose conditions evaluate to non-zero will execute.

Tactical: The following task conditions are evaluated and the next task to execute is the task whose condition evaluates to the highest value.

Variables and algebraic expressions can be used in the branching logic and the value of the variables can be changed by conditions in the model. This gives the user complete control and manipulation of the network flow. Figure 4 is an example of a tactical decision that controls the task sequence based on the status of an emergency indicator.

All of these features work to provide an environment for the model developer that is easy to learn and easy to use. Once the basic concepts are understood, any system or process can be modeled using *Micro Saint*. In addition, users can build models at any level of complexity. Some applications may require a very low-level, detailed definition while for others, a high-level definition is sufficient

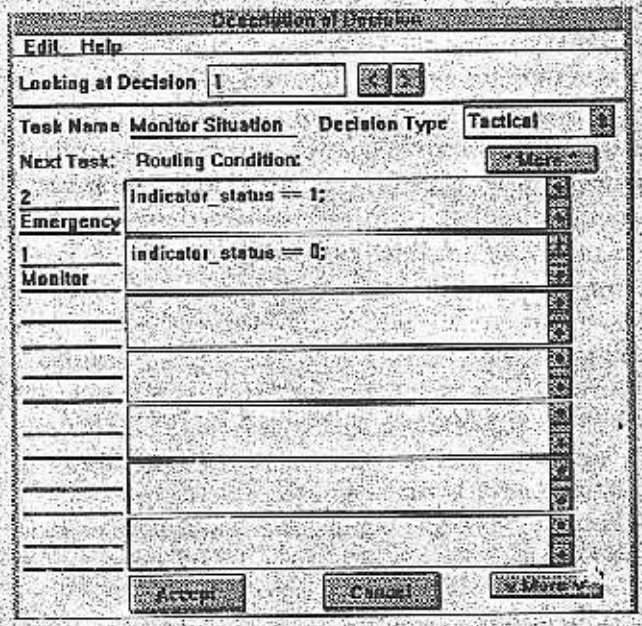

Figure 4. Micro Saint Tactical Decision

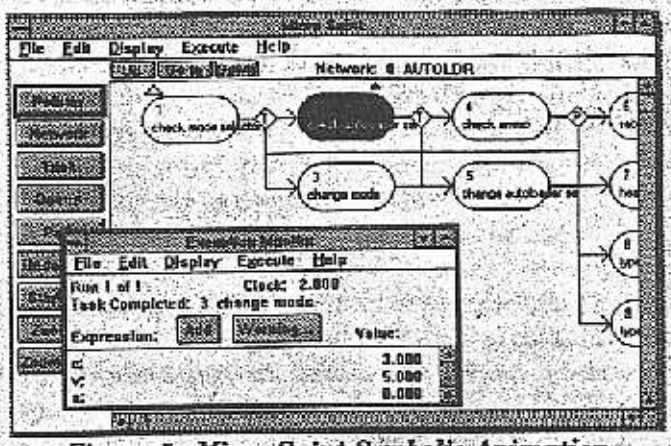

Figure 5. Micro Saint Symbolic Animation

Analysis and Results

People build models to provide insight to, or answer specific questions about, a system or process. Some information can be gained by watching the *Micro Saint* model run. *Micro Saint*'s symbolic animation capability provides an animated view of the network diagram as the model is running. Users can watch as entities flow through the network or wait in queues before being processed. This type of animation is particularly useful in debugging the model the user has just developed. An example of an animated network is shown in Figure 5. *Micro Saint* also provides an iconic animation capability called ActionView that allows users to build a realistic "picture" of their model.

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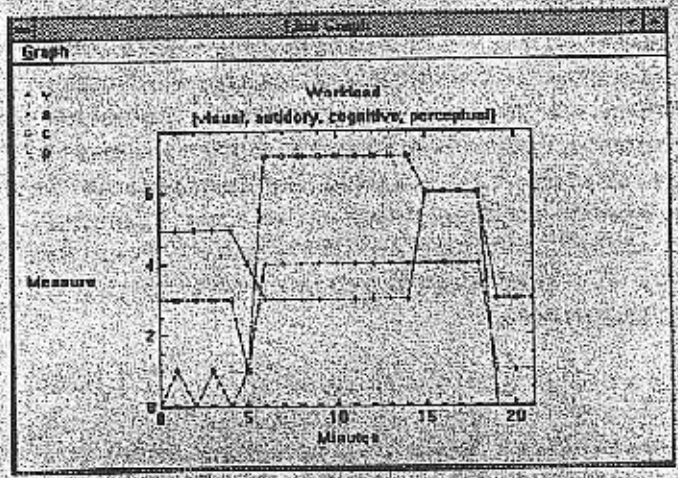

Figure 6. Micro Saint Line Graph

In 1862, long before MANPRINT and human factors engineering, the Ordnance Bureau of the Confederate States Army published the following data on human factors in the Ordnance Manual for the Use of Officers on Ordnance Duty.

Physical Data

Working Power of Men and Horses.

Men. — A *foot soldier* travels in 1 minute,

In common time, 90 steps = 70 yards.
In quick time, 110 steps = 86 yards.
In double quick, 140 steps = 109 yards.

He occupies in the ranks a front of 20 inches, and a depth of 13 inches, without the knapsack; the interval between the rank is 13 inches. 5 men can stand in a space of 1 square yard. Average weight of men, 150 lbs. each.

A *man* travels, without a load, on level ground, during 8½ hours a day, at the rate of 3.7 miles an hour, or 31¼ miles a day. He can carry 111 lbs., 11 miles in a day. A porter going short distances and returning unloaded, carries 135 lbs., 7 miles a day. He can carry in a wheelbarrow 150 lbs., 10 miles a day.

The maximum power of a strong man, exerted for 2½ minutes, may be stated at 18,000 lbs raised 1 foot in a minute.

Mr. Field's experiments, 1838.

A man of ordinary strength exerts a force of 30 lbs. for 10 hours a day, with a velocity of 2½ feet in a second = 4,500 lbs. raised 1 foot in a minute = *one-fifth* the work of a horse.

Daily allowance of water for a man, 1 gallon, for all purposes.

— contributed by Peter Eiser
Frederick, MD

***Micro Saint*, Continued from page 6**

In addition, data can be collected at any time during the model run. Sometimes it is sufficient to save the state of the system at the end of the run. However, in order to gain insight into the dynamic aspects of the system users can "take snapshots" of the model variables any time during the run. These "snapshots" of data can be analyzed using the graphing capabilities within *Micro Saint* (see Figure 6) or imported into another statistical analysis package. Through the results of the simulation analysis and the insights gained, users can assess the relative merits of alternative solutions as well as predict their impact which leads to a better understanding of the costs and benefits.

Summary

In this article we have focused on the *Micro Saint* methodology and the underlying principles of modeling with *Micro Saint*; we have not attempted to cover all of the software features. *Micro Saint* is a powerful tool for evaluating the dynamic issues of systems. It is being used in MPT analysis, human factors analysis, and in the verification of task analysis in support of MANPRINT. Its primary strength is that its intuitive, graphical interface allows users to quickly develop models that accurately represent their system. Users are then able to play "what if" with a variety of inputs to evaluate alternative solutions. This type of analysis provides information that leads to better decisions being made earlier in the design phase which is critical in this era of shrinking military budgets, where the military must do more with less to remain effective.

For more information on Micro Saint contact Lori Hood or Susan Dahl, Micro Analysis and Design, Inc., 4900 Pearl E. Circle, #201E, Boulder CO, 80301.

ODCSPER Coordinator Notes

- **Welcome MAJ(P) Mitchell Howell, Acquisition Corps (INF) ...** Mitch joins the MANPRINT Directorate as Policy Division Chief. He recently completed graduate school at Florida Institute of Technology and previously served in the desert as Operations Officer for the 2-187 Inf BN of the 101st Abn Div (AASLT).
- **MANPRINT Practitioners' Forum '94 ...** Before Forum '93 fades from your memory, help us plan Forum '94. Tell us: What did we do right? What should we change? What improvements do we need to make? Let us hear from you by 1 November 1993.
- **AR 602-2 ...** should be on its way to the printers by the time you read this. An information-only draft version was sent out in August.
- **MANPRINT Directory ...** 2nd Edition is being planned now. Send me your organization charts, phone lists, and any corrections to the current directory.
- **Quarterly quality depends on you. ...** We are not staffed to write articles. So what you see in the *Quarterly* largely depends on what you send in.
- **DCSPI is now DCSPLANS ...** (A.K.A. Deputy Chief of Staff for Plans, Force Integration, and Analysis) MANPRINT Division. Their new location and phone numbers are:

MANPRINT Division, TAPC-PL	RM	Telephone
LTC W. Aldridge	3S07	325-4070
Force Level Branch		
Mr. A. Pridemore	3S11	3200
MAISRC Section		
CPT Prosser		4077
ASARC Section		
CPT(P) Cronk		3203
Automated Info Sys Branch		
Mr. R. Brandenberg	3S07	7501
STAMIS Section		
MAJ Caughran		4076
AIS Section		
Mr. Hodges		4092
Operations Branch		
Ms. D. Lueker	3S15	1560
Training Officer		
CPT Woods		7977
FOOTPRINT		
Mr. Robinett		2092
FAX Number		325-7927

— brought to you by Harry Chipman
ODCSPER Coordinator

Meetings

19 - 20 October 1993
Role of Reliability, Availability, and Maintainability (RAM)
Aberdeen Proving Ground, MD. Contact ADPA at (703) 522-1820, Fax (703) 522-1885 (Refer to Event #441).

28 - 29 October 1993
European Environmental (EROC '93)
Munich, Germany. Meeting will feature concurrent government and industry exhibits. Contact ADPA at (703) 522-1820, Fax (703) 522-1885 (Refer to Event #436).

2 - 4 November 1993
Air Targets & UAVS
New Orleans, LA. Meeting will feature concurrent government and industry exhibits. Contact ADPA at (703) 522-1820, Fax (703) 522-1885 (Refer to Event #442).

29 November - 2 December 1993
15th Interservice/Industry Training Systems Conference (I/ITSC)
Orlando, FL. Meeting will feature concurrent government and industry exhibits. Contact ADPA at (703) 522-1820, Fax (703) 522-1885 (Refer to Exhibit #425).

15 - 18 November 1993
31st Meeting of the Department of Defense Human Factors Engineering Technical Group
San Diego, CA. Contact Loulda D. Murray, 4476 W. Ponds View Drive, Littleton, CO 80123; (303) 798-2617 (*Note: Voice and Fax numbers are identical. To send a fax from your fax machine, do **not** try to establish voice contact first, the machine will recognize the fax signal.*)

MAISRC Oriented MANPRINT Action Officers Course

Raymond Brandenburg and Diana Lueker

In December 1992, the MANPRINT Training Steering Committee approved the development of a pilot MANPRINT Action Officers Course oriented toward Major Automated Information System Review Council (MAISRC) systems. A MAISRC MANPRINT Training Working Group was convened to help develop a draft Program of Instruction (POI). Subsequently, the final POI was developed after review of potential lesson plans and close coordination with the Office of the Program Executive Officer for Standard Army Management Information Systems (PEO STAMIS). PEO STAMIS had agreed to sponsor an initial course.

The pilot course was conducted by the Army Logistics Management College (ALMC) at the Casey Building, Fort Belvoir on 28 June - 1 July 1993. COL Charles B. Gaisson, Deputy PEO STAMIS opened the course. The guest speaker was LTG Peter A. Kind, Director of Information Systems for Command, Control, Communication, and Computers (DISC4). LTG Kind was introduced by Ms. Roscille Nelson, Deputy Director of MANPRINT, Office Deputy Chief of Staff for Personnel. LTG Kind reiterated his support for MANPRINT. He has been a solid supporter of MANPRINT in his previous assignments as Commanding General, U.S. Army Information Systems Command and Commanding General, U.S. Army Signal Center and School. Twenty-seven students attended the course and their comments and critique sheets from the course will be used to determine the strategy for subsequent MAISRC oriented MANPRINT training. This will be addressed at the next MANPRINT Training Steering Committee meeting to be held in October 1993. The success of this pilot course has helped institutionalize MANPRINT as part of the acquisition process for MAISRC systems. For additional information on MAISRC oriented MANPRINT training or MANPRINT training in general, contact Mr. Jim Walsh, MANPRINT Course Director, ALMC, DSN 539-4365 or Commercial (804) 765-4365.

Mr. Brandenburg is the Chief, Information Systems Branch and Ms. Lueker is the Chief, Operations Branch, MANPRINT Division, DCSPLANS, U.S. Total Army Personnel Command (PERSCOM).