MANPRINT BULLETIN

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AMCOS Update

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AMCOS (Army Manpower Cost System) is a family of manpower life-cycle and budget cost models designed to provide the Army with accurate, timely, critical information about the costs of active, reserve, and civilian manpower. This user-friendly system, which can be easily installed on most of the Army's personal computers, puts the power of life-cycle and budget cost estimation directly into the hands of those who need such information. Ease of use is ensured by AMCOS's instant-help screens and extensive menu system.

AMCOS can provide a single, unique answer to complex manpower cost questions. For example, AMCOS can assist in justifying new weapons programs by providing a single cost comparison between buying an existing weapon system and a new one over both of the estimated life cycles. Moreover, AMCOS can provide all of the supporting manpower details by MOS, skill, and pay grades, individual cost elements, and budget appropriation.

AMCOS determines manpower costs based on scenarios defined by each user and on stored cost data. Computerized cost modules can represent Army personnel policies, consider force continuation rates, and estimate both average and incremental costs.

The U.S. Army Cost and Economic Analysis Center has used AMCOS for determining independent cost estimates. In addition, AMCOS is the cornerstone of The Army Force Cost System (TAFCS). The Army Materiel Command (AMC) has established AMCOS as one of its tools for determining manpower cost estimates. AMCOS has also been used to determine what happens to the

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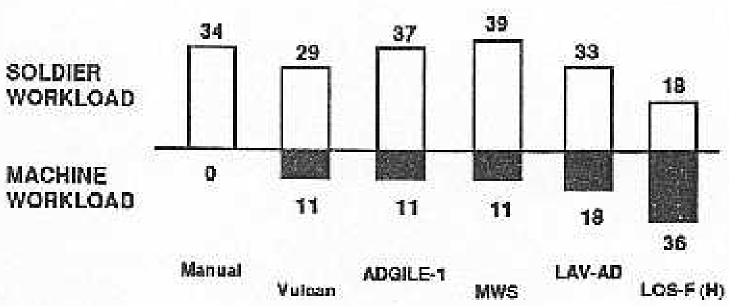
"Remember the Soldier"

ARI: *from page three*



SOLDIER-MACHINE TASK ALLOCATION AND EFFECT ON WORKLOAD RATINGS

Figure 1

evaluation of the LOSF concept, ARI was asked to assess the system's usability from the operator standpoint. Workload ratings of existing systems were compared to that of the new automation-inflenced system. The more complex LOSF concept compared very favorably (Figure 1). Air Defense commanders subsequently included the analysis in the ASARC as part of their proof-of-principle evidence.

MANPRINT in the Field. Avenger was the first "start to finish" system with MANPRINT involvement. MANPRINT was embedded in the RFP and has been tracked through every step to include its initial fielding.

Avenger MANPRINT assessments differed from most test and evaluation efforts preceding it. Traditional methods include pre- and post-test questionnaires, body machine fit measurements (anthropometrics), and Army regulations-based checklists. However, questionnaire data are often too subjective or situation-specific, and can be interpreted many different ways. It is very difficult to make precise recommendations for "system inprovements" with such data. The other two measures are not designed to capture the complex events which occur in a fast-moving combat situation. In place of these measures, SRL used time and error data--recording what happened, when and how often. Such information is needed to diagnose, prioritize and correct system problems.

The key to this type of analysis is translating the flow of events into the separate steps of a system's operation. This lets us identify and count where and when certain serious errors occur. More importantly, it lets us study the cause-and-effect relationship between operator action and system performance. For Avenger testing, the critical fire engagement sequence was chosen for study. A combination of gunner station audio-video, observer and computerized data collection and reduction formed the data base.

Table 1 below presents key engagement tasks in terms of the probability of correct performance of each step alone and for the overall sequence. Errors at each step were diagnosed in terms of MANPRINT cause, categorized by domain, and then classified as potentially correctable or not.

Examples of MANPRINT errors correctable through training are "misidentification of targets" or "innappropriate use of search procedures." A MANPRINT error correctable through improved HFE is "firing when the target is out of range," a step which could be prevented by automated firing lock out based on available electronic information.

	UNCORRECTED MANPRINT ERRORS		*MANPRINT ERRORS REMAINING AFTER CORRECTIONS*	
ENGAGEMENT EVENT	PROBABILITY OF EVENT SUCCESS	CUMULATIVE PROBABILITY	PROBABILITY OF EVENT SUCCESS	CUMULATIVE EVENT SUCCESS
Detection	.920	.920	.958	.958
Acquisition	.993	.914	.998	.956
Identification	.984	.899	.997	.953
Tracking	.940	.845	.959	.914
Firing (Launch)	.935	.790*	.993	.908*

PROBABILITY OF SUCCESS IMPROVES FROM .790 TO .908

IMPACT OF MANPRINT ERRORS ON ENGAGEMENT SUCCESS

Table 1

ARI: *from page five*

MANPRINT R&D Demo Matrix

RESEARCH TASKS / DEMO SYSTEM	FAAD C3I	LOS-F(H)	PMS	NLOS-AD	Patriot	ASM	LH	MH-60 & MH-47	ATES	UH-60	MSE	SINCGARS	MLRS	Aquila RPV	HIP	Stingray	Stinger	Blackhawk UH-60	UAV	ATAS	MCS	PLS
Controlling Excessive Crew Workload		●	●							●				●		●	●	●				
Soldier-System Effectiveness in ADA	●	●	●	●	●											●	●					
Task Performance Modeling		●		●							●				●							
Soldier Errors in Automated Weapons													●									
Performance-Based MPT Estimation					●	●																
Soldier Performance in the CBRS						●																
Assessment of Manned System Performance								●														
MANPRINT for Materiel Developers							●															
Soldier-Equipment in MOS Design											●	●										
Reducing Aviator & Maintainer Requirements							●	●	●													
Soldier-System in Force Development Testing											●	●							●	●	●	●

Matrix Tech Base R&D with Tech Demos
Table 2

When MANPRINT "corrections" were applied to operational test data, there was a significant potential impact on overall system performance. As Table 1 shows, the chance of completing the engagement sequence increases from 79% to 90.8%. Using a missile which can hit its target 90% of the time, the overall system performance on a 1,000 target day increases from a target kill of 711 to 817.

These results show an improvement of nearly 15% in weapon system effectiveness. This increase can be related to MANPRINT corrections made early and throughout the life of the weapons program. Another way to look at savings would be that 15% fewer fire units are necessary to do the same job. With weapons, manning, and training costs, the savings for the Avenger program alone are a conservative $60 million. The savings in protected combat assets and lives cannot really be measured.

The MANPRINT Payoff

Major proponents of ARI's MANPRINT projects include OPTEC, Program Managers, TRADOC System Managers, and the Army test boards. Consistent supporters have been the combat and training developers at the various TRADOC schools. Table 2 above profiles mutual support efforts.

The soldier-system environment is growing more complex as technology introduces both new threats and capabilities. The Army faces force structure changes and demographic shifts. Clearly, future acquisitions must have an effective way to manage the integration of its most valuable resource, the soldier. The MANPRINT program works to enhance overall soldier-system effectiveness by identifying soldiers' capabilities and building the hardware-software system around them. The savings in human and materiel resources are beginning to be realized. MANPRINT provides the Army with the best means available to help soldiers meet growing performance standards which must be met under an ever-widening set of conditions.

For more information, contact Dr. Rene dePontbriand, U.S. Army Research Institute, Systems Research Laboratory, DSN 284-8891.

MOVERS & SHAKERS

PEOPLE IN THE NEWS

- **Barbara Frank** of the HQ DA MANPRINT office has been promoted and reassigned to the DAIG Audit Follow-up Team. We thank Barbara for her great work and wish her well in her new position.

YOUR INPUT IS NEEDED!

Have announcements or news about people in your workplace that might be of interest to others in the MANPRINT community? And of course, we're always on the lookout for good articles! Contact Mr. Harry Chipman, HQDA (DAPE-MR), Washington DC 20310; (703) 695-9213.

ECA in Action:
A Cost-Saving Methodology

Early Comparability Analysis (ECA) is based on operator, maintainer and repairer tasks associated with predecessor and/or reference systems. ECA helps determine which tasks associated with these systems are manpower, personnel and training (MPT) resource intensive, and focuses on appropriate MPT solutions to these high driver tasks. Eleven ECA applications have been completed or are near completion. These applications contain analyses of 9,621 tasks, with 427 of which have been identified as high driver tasks. Four additional ECAs have recently been initiated.

These applications demonstrate that ECA is a proven MANPRINT tool that can pay for itself when high drivers on systems are identified and solved early through changes in design concepts. Costs are far greater for both government and industry when an engineering change proposal (ECP) is required at a later acquisition milestone. Identification of high driver tasks along with MPT solutions to the deficiencies they present allows combat developers to introduce MPT considerations early in the design process and to find solutions before old problems are repeated in new system development.

Combat and training developers have used ECA to address MPT issues in planning, program and requirements documents. U.S. Army Quartermaster School personnel described the ECA results for the Mobile Kitchen Trailer (MKT), predecessor to the follow-on mobile kitchen under development, as "surpassing the sponsor's expectations." High driver task analysis and recommendations have linked MKT problems to hardware deficiencies that will be designed out of the new system. ECA recommendations have also been incorporated into requirements documents for the new kitchen. Quartermaster School personnel used high driver task analysis and system design recommendations from the All Terrain Lifter Articulated System (ATLAS) ECA to develop input to their Materiel Handling Equipment Modernization Plan (November 1990). ECA results, along with other inputs and analytical resources, helped determine that fielding ATLAS would lead to savings in manpower needed to operate and maintain the system, and savings in training manhours, as compared to the predecessor forklifts. ECA results were of greatest benefit for training projections. ATLAS ECA results have been incorporated into the System MANPRINT Management Plan (SMMP), the draft Required Operational Capability (ROC), (renamed Operational Requirements Document [ORD]), and the draft System Training Plan (STRAP). In addition, U.S. Army Intelligence School personnel have incorporated ECA recommendations for the Ground Surveillance Radars (GSR) into the 1990 Operational and Organizational (O&O) Plan for the Lightweight Battlefield Surveillance Radar (LBSR). The ECA results will also be used to identify and justify operational characteristics for the draft LBSR ORD.

Combat and training developers have used ECA results to address MPT issues in MOS decisions, and in new system training plans. Quartermaster School personnel described the MKT ECA results as "instrumental in MOS decisions for supporting documents, and for training purposes." Intelligence school personnel plan to use ECA results to select critical tasks for training for MOS 96R, Ground Surveillance Systems Operator, and to revise the MOS 96R Program of Instruction (POI), increasing training time for tasks in accordance with high driver recommendations. ECA results for the Lighter Air Cushion Vehicle - 30 ton (LACV-30) were instrumental in MOS decisions. The high driver task analysis produced a recommendation for an additional skill identifier (ASI) for MOS 68B, Aircraft Powerplant Repairer, to train mechanics on unique and critical job responsibilities resulting from placement of a turbine engine used on helicopters on an ocean going vessel (LACV-30).

An added bonus of ECA is greater communication between proponent personnel responsible for designing a follow-on system for the Army. Quartermaster School personnel established valuable points of contact within the Directorates of Training and Doctrine (DOTDs) of other Army proponent schools when sponsoring MKT and ATLAS ECAs.

ECA also serves as a tool for collecting individual soldier viewpoints that can validate proposed design changes. Comments collected from operators and maintainers of the MKT and predecessor forklifts for the ATLAS helped confirm needed design changes on a variety of sub-systems, from roof assemblies and canvas parts on the MKT, to brake sub-systems and cab assemblies on predecessors.

Early identification of high drivers for MPT benefits both government and industry. The average cost of a contracted ECA is $52,500, while the hardware costs of an engineering change proposal (ECP) to fix a problem after Milestone I can range from about $50,000 to the multi-million dollar level. Adminstrative costs to initiate and implement the ECP and provide for safety and engineering oversight add to the government's cost. A single ECA application yields, on the average, a total of 39 high driver tasks per predecessor system. If even one of the high driver task solutions eliminates the need for an ECP, the ECA can pay for itself. When compared to the range of costs for ECPs, ECA offers a clear advantage to both government and industry.

The Early Comparability Analysis Procedural Guide, June 1991, contains guidance for conducting an ECA. It contains suggested resourcing strategies, to include allocation of internal resources for an in-house application and allocation of resources under AR 5-5, TRADOC Study Program, for TRADOC activities. Industry representatives may obtain a copy of the Guide through the Defense Technical Information Center (DTIC). Government representatives may obtain a copy from Deputy Chief of Staff for Personnel Integration (DCSPI), ATTN: TAPC-PI-MPT (Ms. Van Hoff), 200 Stovall St., Alexandria, VA 22332-1345; DSN 221-2093/COM(703) 325-2093.

America's *Five* Services

Norman R. Augustine
Martin Marietta

Editor's Note: The following article was reprinted from the July-August 1991 issue of Army RD&A Bulletin.

Our country's stunning victory in the Persian Gulf is a tribute to all five branches of America's armed services. The Army, Air Force, Navy and Marines are the four branches that immediately come to mind. The fifth branch, though we don't often think of it as such, is the U.S. defense industry. We need all five to maintain our defense preparedness.

Without the Navy, we never would have been able to get most of our forces to the battlefield. Without the Air Force, we never would have been able to gain total mastery of the skies and pound the Iraqi ground forces from above. Without the Army and Marines, we never would have been able to deliver the knock-out punch in the ground war. And, without the defense industry, we would never have had the high technology capability that acted as a true force multiplier against Iraq's numerical and home-court advantages.

Before the Gulf War started, the combat area ground forces of Iraq were larger than those of the U.S. Army and U.S. Marines combined. Conventional tactics say that a well-prepared defending force can stalemate an attacker three times its size. Superior American technology helped make that principle itself stale.

Technology has worked that way throughout history. The stirrup, for example, simply by today's standards, was an enormous breakthrough. For the first time, a knight on horseback could secure his feet and thereby control a lance with great precision.

The wonders of the stirrup were minor when compared to the power the longbow gave the English archers against the French in the Battle of Crecy in 1346. The longbow became outdated by the invention of gunpowder and, eventually, the rifle. The rifle's dominance was in turn blunted by the power of the machine gun. This technologically-superior weapon gave the Germans victory in the Battle of the Somme during the First World War. The British, using outdated infantry tactics, advanced battalion after battalion against entrenched German machine guns and promptly lost some 10,000 of their finest troops.

The machine gun produced a stand-still among well-entrenched forces until the invention of the tank, which could overwhelm fixed positions. Germany's highly-mobile tank armies at the beginning of the

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Second World War swiftly overwhelmed the heavily fortified Maginot line.

During the World War II, it took five tons of air munitions or three tons of artillery to destroy a single tactical target. The same ratio held true during Korea and Viet Nam. Over 850 sorties and 250 tons of conventional bombs failed to destroy a single span of the Thanh Hoa bridge in Viet Nam during the early years of the war. A single laser-guided bomb in use near the war's end destroyed the bridge in just one attack without the loss of aircraft or crew member.

Each new military advance eventually finds its match in a countermeasure. We can be sure that the technologies that proved so decisive in the Persian Gulf—lasers, infrared detectors, space surveillance, precision-guided missiles, night vision, stealth—will all generate countermeasures.

That's why we must continually improve our military capability. If we don't, we'll find ourselves in the position of the French at the Battle of Crecy or the British on the Somme. Indeed, most of the technology used in the Gulf War was of 1970s vintage—paling in comparison with what is being pursued in American laboratories now. Smart weapons of today will soon give way to brilliant weapon of tomorrow.

President Eisenhower, in a generally-forgotten passage of his oft-quoted speech about the military-industrial complex, said that "we can no longer risk emergency improvisation of national defense; we have been compelled to create a permanent armaments industry of vast proportions."

The systems we saw at work in the Gulf demonstrated exactly what he must have meant. They were funded and built over an 20-year period. It takes an average of eight years to develop a new weapon system and another five-to-10 years to acquire it in significant quantities. In the case of the Patriot missile, it took a quarter of a century to get the system that was used so successfully for the first time in the Gulf. Yet when the war began, we barely had Patriot at all to counter the Scud attack. The Army and industry's efforts to deliver the system before January 16th gave new meaning to just-in-time manufacturing.

Technology also takes money. But it's money well spent. It has the saved lives of countless numbers of our armed forces and the people they defend. The choice is simple: either we spend the money on technology before a war starts, or we pay the price after it begins. In the latter case, we pay in a much more precious currency—that of the blood of our men and women in uniform.

The invasion of Kuwait presented us with a true "come-as-you-are" war. Fortunately, America was prepared. Our troops were well led, well trained, and well equipped. Contrast that with the experience of our soldiers at the outset of the World War II when they had to train with broomsticks "rifles" and old automobiles with the word "tank" painted on their sides.

It is the responsibility of the fifth armed service—the defense industry—to develop technologies that endow the other four armed services with superior fighting power. But the defense industry cannot do this without support from our political leaders and the public, and, indeed, for its sister services.

During the development of virtually every major weapon system embodying any reasonable advance in the state-of-the art there comes a time, no matter how ably the program is managed, when seemingly overwhelming problems are encountered. In such cases, it invariably becomes easier—and far more popular—to cancel the program, and start over with a new system which would—as we delude ourselves—have no problems. We came within millimeters of doing this on the Patriot, which was nearly cancelled several times. The same is true of the Cruise missile, the M-1 tank, the Bradley Fighting Vehicle, the Blackhawk, the Apache, Tomahawk, and AWACS.

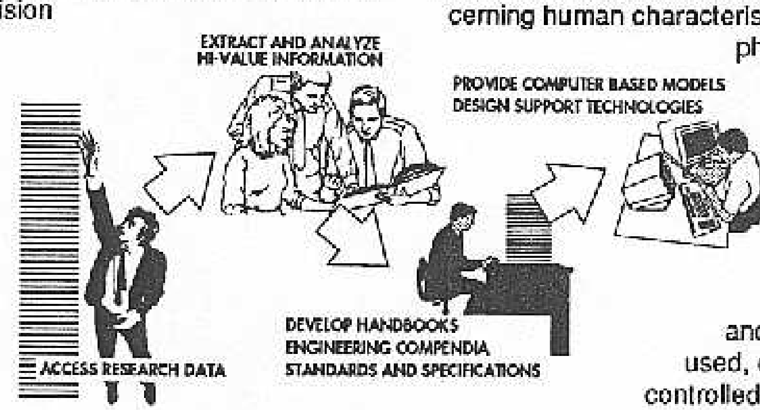
Each of these systems proved itself invaluable in the Gulf. Yet, at one time or another, cancelling these programs and starting over would have been more popular with the media, the public, the president, and sometimes even with parts of the military services themselves. Fortunately, different counsel prevailed. That is not to say that once in a while there is a system that truly is a failure and has no realistic chance of success. Such projects should be cancelled. But in the great majority of cases, the correct answer is to work through the problems--or "tough it out"—just as an Army does in any type of combat.

To fail to exhibit this perserverance guarantees that we will have ill-equipped armed forces backed with a long trail of half-completed R&D projects. We narrowly avoided this in the Persian Gulf War.

More About CSERIAC

Dr. Lew Hann, Dr. Larry Howell, and Mike Gravelle
Crew Systems Ergonomic Information Analysis Center

Not so long ago, in a galaxy not so far away, an Army engineer needed to determine the performance effects of exposure to varying levels of hydrogen chloride (HCl). During an evaluation of the High Mobility Multi-Wheeled Vehicle's (HMMWV) pedestal-mounted Stinger gun, the engineer detected HCl gas that discharged from the gun chamber after it was fired. Since Army personnel would be operating the Stinger and driving within the semi-encapsulated HMMWV, the engineer was concerned about the effects of HCl on operator performance (e.g., vision, manual control, decision making).



Fortunately, the engineer contacted CSERIAC, the Crew System Ergonomics Information Analysis Center. Shortly thereafter, he was directed to many sources, including NIOSH/OSHA guidelines, several industrial hygiene and toxicology handbooks and technical reports, and subject-matter experts in toxicology. Through these sources he learned that short-term exposure to HCl gas causes eye irritation, severe burns, and visual impairment, which sometimes results in permanent damage or loss of eyesight. In addition, exposure to the gas was found to immediately cause severe irritation of the upper respiratory tract resulting in coughing, burning and choking. Specific information was provided to the engineer that described these debilitating effects at various HCl concentration levels.

Human-performance related information like this is critical in the design of most person-machine systems. MANPRINT practitioners, as well as DoD and Government human factors/ergonomics and system design engineers, must have ready access to human information and ergonomics/human factors expertise to help analyze needs and advise decision makers in designing and selecting military systems.

The current information expolsion has made it increasingly difficult for design engineers and other system decision makers to locate, assimilate, and efficiently use the available crew system ergonomics information. CSERIAC provides a cost-effective means to help incorporate human-centered information into developmental systems. CSERIAC serves as a gateway to human performance information.

Specifically, crew system ergonomics information is scientific and technical knowledge and data concerning human characteristics, abilities, limitations, physiological needs, performance, body dimensions, biomechanical dynamics, strengths, and tolerances. It also includes engineering and design data concerning equipment and systems intended to be used, operated, maintained, or controlled in sea, land, air, and space environments.

CSERIAC operations are guided by technical and scientific leaders from the Army, Navy, Air Force, National Aeronautics Federal Aviation Administration (NASA), and Federal Aviation Administration (FAA).

These experts provide advice on operations in specific areas of human performance information analyses, workshops, conferences, technology products and human factors community needs. These leaders and other subject matter experts provde CSERIAC with the capability to respond to technical questions and produce state-of-the-art information management.

For more information and/or to request help from CSERIAC, contact Dr. Larry Howell, CSERIAC Program Office, AL/CFH/CSERIAC, Wright-Patterson Air Force Base, OH 45433-6573; (513) 255-4842 (DSN 785-4842).