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An Intelligent Pilot-Vehicle Interface for the Counter-Air Helicopter

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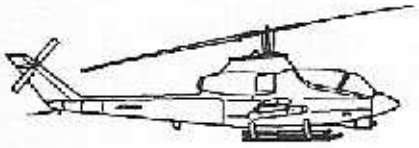
One of the many challenges facing the human factors engineer (HFE) is the development of an intelligent pilot-vehicle interface to assist the pilot of counter-air helicopters. The intended product, labeled the "adaptive cockpit" or the "pilot associate," will be a computerized electronic copilot that provides cognitive decision aid to assist the pilot in those critical mission support functions that are necessary for survival over the modern battlefield. The challenge to the human factors engineer (HFE) is to develop an intelligent hardware interface between the pilot and the electronic modules to optimize the total soldier-machine system performance. The intelligent interface will have to incorporate many of the automated techniques used by HFEs in designing crew stations to dynamically tailor the interface for the pilot in real time during a mission.



The recent growth in computer technology and the related field of artificial intelligence (AI) has expanded the potential role of computing machines in the crew station cockpit, allowing the HFE to stress the engineering in the job description as never before. The automated techniques used by HFEs and scientists in designing crew stations (task analysis, workplace layout, work load analysis, experimental design and statistical analysis, and bioinstrumentation of the human) are now augmented with AI concepts to assist the pilot during a mission. The very HFE tools that have been developed to ensure the best crew station design for the pilot performance are now being integrated into the actual aircraft cockpit to help in real time as he actually performs a mission!

The mission facing the pilot of a counter-air helicopter is most demanding. The task involves

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finding and engaging an enemy helicopter as elusive as himself in a flight environment saturated with military countermeasures. The flight domain, made possible by the unique properties of hover, sideways, backwards and vertical flight, is by necessity for survival, nap of the earth from 1 to 15 meters above the ground to take advantage of the local terrain and ground cover. The hazards are numerous: power lines, utility poles, trees, and other obstacles to flight, adverse weather and poor visibility, surface-to-air missiles, firearms and small caliber antiaircraft fire, and of course, the other helicopter.

Because of these challenges, one version of a new lightweight, high performance, experimental helicopter series being developed by the Army will likely be an advanced counter-air fighter. This helicopter will be equipped with hardware needed to perform the combat role: an early warning system, a situation awareness digital map display, multifunctional system status displays, advanced sensors (for navigation and target detection), an advanced flight control system, a side-arm controller, night vision pilotage system, a helmet-mounted display, and air-to-air fire-and-forget missiles.

The addition of a high tech "adaptive cockpit" design will allow the pilot to focus his attention more on his specific mission and less on flying the aircraft. Essentially, the electronic copilot will have programmed AI acquired from analysis and knowledge-based engineering residing in expert system modules that are dedicated to mission support functions. These modules, which will have access to appropriate data bases and the output of the other systems, will perform such mission functions as situation awareness assessment, system status assessment, mission planning, and tactical planning. An executive module will be used to resolve conflicting demands and to update mission goals as perceived needs change, and will also provide pilot-vehicle interface management.

The expert systems modules will function as follows: The situation assessment module will use digital map terrain data and the tactical information received electronically from the communication net and the on-board sensors to assess the impact of threats on the mission. Similarly, a status assessment module will monitor the status of the aircraft systems: propulsion, armaments, sensors, and life support for potential failures. A tactical planner module will plan countermeasures and evasive maneuvers in the face of an immediate hostile threat. The mission planner module will plan routes and allocate resources for objectives.

Through the pilot-vehicle interface module, the pilot will receive all information processed by the electronic co-pilot and demand execution of mission-controlling decisions. This module will direct the display of status alerts, information, and requests for decisions to the pilot. The module should present all information in a dynamic format designed to optimize the performance of the pilot. It must be an AI expert system that embodies human factors knowledge about the crew station arrangement, work load tasks scripts, and human capacities and limitations about processing visual and auricular information.

The interface module will dynamically tailor the information to be presented on the basis of inferences about the pilot's intent and capacity as determined from monitoring his state and actions. It will monitor the pilot's control action inputs from the controller arm movements and switch selections from programmable panel switches, touch panel displays, or automatic speech recognition of voice commands. Through bioinstrumentational links, the pilot's cognitive state will be monitored through eye movements and fixation patterns, and electroencephalograms; his physiological state will be determined through breathing rate, electrocardiograms, and speech analysis. The module will infer the task intention of the pilot from this information and knowledge of the system goals as directed by the mission executive, and will assess his work load and errors and his task performance capability. The module will then display cognitive decision aiding to maximize the pilot's counter-air mission performance.

The challenge to the HFE, as we begin to redefine the role of the machines in the next century through increased computing power, artificial intelligence, and robotics, is to produce an intelligent interface with the human that seems so natural that we invariably ask the question: where resides the "soul" of the machine?

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New in Print

Design for Success: A Human-Centered Approach to Designing Successful Products and Systems

William B. Rouse. *Design for Success: A Human-Centered Approach to Designing Successful Products and Systems.* New York: John Wiley & Sons, Inc., 1991. 270 pp.

Design for Success offers a comprehensive, methodical framework for the human-centered design of complex systems. This new approach to system design includes four phases—naturalist, marketing, engineering, and sales and services—and covers the entire product life cycle, including:

- Understanding users' needs and preferences
- Concept and market evaluation of alternative ways to satisfy these demands
- Detailed design and engineering evaluation of products and systems
- Fielding and on-going in-use evaluation

A wide variety of methods and tools are discussed within this methodological framework, and its use is illustrated with several case studies of actual applications in a variety of industries. This book makes human-centered design very concrete and readily applicable to practical and realistically complex design problems. Its use of methods is supported by much "how-to" guidance in the form of case histories, almost 100 figures and tables, principles and guidelines to provide a "toolbox" with which to pursue design.

The material in this book is drawn from ten years of development, utilization, refinement, and extension of concepts and methods. These efforts have occurred in a variety of fields, from commercial and military aviation, the process and power industries, and manufacturing, to the marine industry and communication, making this book both useful and more human-centered.

Editor's Note: William Rouse was a major contributor to *MANPRINT: An Approach to Systems Integration*, which was edited by Dr. Harold R. Booher, Director of the U.S. Army's MANPRINT Office. Dr. Rouse wrote the chapters entitled "Designing for Human Error: Concepts for Error Tolerant Systems," "Training and Aiding Personnel in Complex Systems," and co-wrote the book's conclusion, "MANPRINT as the Competitive Edge," with Dr. Booher.

? DID YOU KNOW?

● MANPRINT is strengthened in the new DoDD 5000.1, Defense Acquisition, DoDI 5000.2, Defense Acquisition Management Policies and Procedures, and DoDD 5000.2M, Defense Acquisition Documentation and Reports. MANPRINT is the Army's Human Systems Integration program and no fundamental changes to the program are anticipated. Additional details appear in HQDA message 031600Z June 91, subject: MANPRINT and DoD Acquisition Guidance.

● The DoD HFETechnical Group met on 14 May 91 at Natick RD&E Center. The Acquisition Subgroup, chaired by Bruce McCommons of HEL, provided policy updates on issues affecting HFE and MANPRINT in the acquisition process. DoDD 5000.1, DoDI 5000.2 and DoDD 5000.2M were addressed at length among the 38 senior Army, Air Force, Navy and industry representatives.

MOVERS & SHAKERS

PEOPLE IN THE NEWS

• **LTC Glen Hewitt** of the MANPRINT Office is retiring and will be joining Atlantic Research Corporation. We appreciate all of his hard work on our behalf, and wish him well in his new civilian career.

• A couple of new MANPRINT Points of Contact (POC): The new POC at CECOM is **Ms. Rita Dodd**, who is replacing Lucille Tanguay. The new POC at Natick RD&E Center is **Ms. Bonnie Jezior**, replacing Dr. Rusty Warren.

Have any news about people in your workplace that might be of interest to others in the MANPRINT community? Send us the info and we'll print it! Contact Ms. Barbara Frank, HQDA (DAPE-MR), Washington DC 20310; (703) 695-9213.

MANPRINT in the French Army

LTC Glen Hewitt
MANPRINT Directorate, ODCSPER

During the 1990 US/French Staff Talks sponsored by Headquarters, TRADOC, the French delegation expressed interest in knowing more about the MANPRINT program. As a result of this interest, a three-member US delegation participated on 8-9 April 1991 in a Subject Matter Expert Exchange with members of the French Technical Section of the Army at Camp Satory, Versailles. State Department personnel translated US presentations and an interpreter assisted in the formal exchange. French attendees included experts in human factors/ergonomics, materiel acquisition, feasibility studies, and land weapon systems. The US delegation included representatives from TRADOC, AMC, and HQ Department of the Army (DA).

During the two-day exchange, both US and French delegates identified their respective roles and objectives in the materiel acquisition process. The US delegation provided the background of the MANPRINT program and detailed briefings from the perspectives of the combat developer, materiel developer, and the MANPRINT program sponsor at HQ DA. Each US representative offered an accounting of the procedures by which the MANPRINT process is carried out. Each also identified constructive recommendations that may be applied to the establishment of a similar MANPRINT program in the French Army.

Discussions between the two parties demonstrated the commonality of purpose between the US MANPRINT program and the French ergonomic program. Despite differences in the way the US and French Army are organized for materiel development, several similarities emerged. Most notable were some of the problems encountered in establishing a program that achieves the objective of influencing equipment design. French representatives asked many insightful questions about the MANPRINT program and its technical parameters. Representation from all three US organizational entities proved valuable in addressing their inquiries. From the exchange, items of interest include:

a. US representatives found that the program in France is not as fledgling as expected. While their MANPRINT-type program was established only three years ago, the human factors discipline has a well-established and well-placed group of officers and civilians involved in materiel acquisition. Further, the organization is staffed with human factors experts that have worked in the area for many years. They are a highly professional group with sound technical skills and broad weapon system experience.

b. The French showed great interest in lessons learned from Operation Desert Storm, as well as the lessons learned from the institutionalization of the MANPRINT program. Curiosity was abundant about indicators, both positive and negative, of the value-added of human considerations in equipment design. Systems such as Patriot, JSTARS, and Apache provided examples of manpower, personnel, and training success and difficulties. Special interest was expressed in the efforts undertaken to collect the data concerning human performance during combat operations. The French were informed that our ongoing data collection effort (being conducted by HEL under the auspices of OUSD (A) in SWA) would not likely report out for some months.

c. The US and French found that they had similar obstacles in accomplishing the desired results from the respective programs. Some of the more troublesome related to organizing and distributing human performance data, developing and maintaining technical tools for early analysis, establishing useful standards and specifications, and documenting requirements for industry. Procedures established and endeavors undertaken by the US to diminish these hindrances were discussed. It was agreed to use the efforts conducted under NATO Research Study Group 21, Panel 8 (sponsored by OSD [FM&P]) to share successes in resolving these common difficulties.

The candor of the exchange enhanced the productivity of the talks and opened the way for future exchanges beneficial to both the US and France.

TQM and MANPRINT

Diana Lueker
US Army Personnel Integration Command

As we move into the nineties, there is growing realization that some previously accepted management practices need major reshaping if this country is to retain its world leadership role. Total Quality Management (TQM) and MANPRINT are two complementary management philosophies in this restructuring process.

TQM is a management philosophy that involves continuously improving performance at every level and in all areas of responsibility by building and sustaining an organizational culture committed to continuous improvement. Improved performance is directed at satisfying such broad goals as cost, quality, schedule, and mission need and suitability.

TQM is particularly relevant in the materiel acquisition area, where emphasis on quality is an even greater concern as resources--both monetary and human--decline. Recently-revised directive (DoDD 5000.1, Defense Acquisition); instruction (DoDI 5000.2, Defense Acquisition Management Policies and Procedures) and manual (DoD 5000.2-M, Defense Acquisition Documentation and Reports) prescribe requirements for a Human Systems Integration (HSI) program to help meet this challenge. Much like the Army MANPRINT Program, HSI focuses on the role the human resource element has in the materiel acquisition process. DOD recognition of this idea is a significant milestone.

Like TQM, MANPRINT strives for improvement in quality, with a goal to enhance total system performance. By applying management methods to influence system design and acquisition, the combination of hardware performance and soldier performance, in a realistic environment, can be improved to ensure optimum system performance. MANPRINT emphasizes the human element as an integral part of the design process. Designing the best total system at the least cost in manpower, personnel, and acceptable levels of training can be accomplished by ensuring those elements, as well as human factors, health hazards, and safety, are examined continuously during the materiel acquisition process.

TQM and MANPRINT have other similarities. While TQM focuses on organizations and MANPRINT focuses on man-machine interface, both concepts involve processes that identify means of improvement. Monitoring performance, proposing and implementing solutions, and evaluating the effectiveness of proposed solutions are central parts of each process. Both TQM and MANPRINT recognize people as the most important resource. If properly implemented, both create constructive working relationships and teamwork.

A key tenet of TQM is that quality can be improved by controlling the variation inherent in all processes. If processes are consistent, products will be consistent. By limiting the range in which functions can be performed, the range in which variations can occur is narrowed. In MANPRINT, defining the parameters in which a system can be designed (through the target audience description [TAD]) will limit the potential for designing systems beyond the capabilities of the soldiers available to operate, maintain, and support the equipment.

The 5000-series directives outline DOD requirements for "quality" in three interconnected parts: (1) Quality of Design (effectiveness of the design process to capture and translate operational requirements into design requirements that can be manufactured consistently); (2) Quality of Conformance (effectiveness of the design and manufacturing to execute the requirements and process specifications); and (3) Fitness for Use (effectiveness of design, manufacturing, and support processes to deliver a system meeting the operational requirements under all conditions).

While MANPRINT takes a different approach than TQM, it also attempts to ensure quality goals are met. MANPRINT recognizes that error and variability in system performance are driven mainly by human beings and are correctable through management and design focus on process and product, thereby improving quality. The TAD portion of the System MANPRINT Management Plan (SMMP) is an example of how MANPRINT helps to control design variation

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TQM: *from page five*

effectively. The personnel characteristics and abilities of the system user as defined in the TAD help establish the system design parameters and therefore, can limit total system performance variation and help achieve the MANPRINT goal of optimizing overall system performance.

Both TQM and MANPRINT stress "the earlier the better" with regard to their utilization. The earlier an organization discovers errors, the lower its cost for process correction (TQM). Early identification of system design flaws allows changes to be implemented that will increase total system performance at the least cost (MANPRINT).

Perhaps the most important similarity is that both philosophies require dedication, understanding and commitment from leadership to succeed. Dr. Harold R. Booher in his book, *MANPRINT: An Approach to System Integration*, states "Quality leadership must start with competence and ethical values, progress to understanding, and then to commitment. Without ethics no honest concern exists for customer or employee, and there is no long-term focus. Without competence, understanding is unlikely; and without understanding, commitment is meaningless."

For their many similarities, MANPRINT and TQM are two separate concepts. The scope of each program is quite different, as are their objectives. TQM focuses on all processes with the objective of continuous improvement in quality. MANPRINT is targeted on the system design and acquisition process with the goal of enhancing total system performance. Due to costs for educating and training all levels of the organization, start-up costs for TQM are significant. Initiation of a MANPRINT program, on the other hand, requires minimal funding.

MANPRINT or MANPRINT-like programs will prosper as TQM matures. Through MANPRINT, the right equipment will be operated, maintained and supported by the right people. Thus, TQM becomes easier as MANPRINT expands. The climate for one lends support to the other. Motivation is the key driver of both concepts—improved quality and improved performance. While the Army works to institutionalize these philosophies and expand their use throughout the materiel acquisition community, a basic commitment must be made. Top-down implementation of these programs is key to their success. TQM must have management support to be effective. Likewise, MANPRINT cannot be fully successful without management acceptance and utilization. The concepts must be believed, not merely quoted, as we restructure the management practices needed to help the country retain its world leadership role.

For more information, contact Ms. Diana Lueker, USAPIC,200 Stovall St., Alexandria, VA; (703) 325-2096.

MANPRINT NOTES

From the MANPRINT Program Office

■ **Family of Medium Tactical Vehicles MANPRINT Assessment.** FMTV has been approved to proceed to the ASARC. ASARC was convened on 13 May and reconvened on 10 June to resolve remaining issues. Primary MANPRINT concern is the Rollover Protection System (ROPS). Two of the three contractors' prototypes appear to have some type of inherent rollover protection. MANPRINT was a separate major area for source selection.

■ **MANPRINT Enhancement Study Completed.** The MANPRINT Enhancement Study, which was conducted from August 89 to May 91 by Science Applications International Corporation, has been completed. The study's purpose was to identify and recommend strategies to improve the effectiveness of the methods by which the MANPRINT program meets its overall objective. The published results of the study, *MANPRINT 2000: Program Assessment and Enhancement,* enumerates 88 enhancement recommendations under an umbrella of five implementing strategies. These are: revitalize human systems integration (in consonance with new DoD acquisition directives) in the design of materiel; demonstrate to PEOs and PMs the cost versus the benefit of conducting MANPRINT activities and analyses; initiate the establishment of a national work force skilled in human-system integration; delineate technology base opportunities to improve human performance trade-off methodologies and capitalize upon emerging critical defense technologies; and advance concepts for enhanced manpower and personnel utilization and unit effectiveness through organizational design alternatives. Study results were developed from the analysis of records, reports, interviews and questionnaires completed by industrial manufacturers and government agencies participating in defense system acquisition.

ADPA Sponsors MANPRINT and Systems Integration Conference

Nan B. Irick
Fu Associates, Ltd.

The MANPRINT and Systems Integration Conference was held 23-24 May 1991 in Arlington, Virginia. The symposium's aim was to emphasize the MANPRINT philosophy and to challenge those in attendance to apply it from both an organizational and a technical perspective. Ninety representatives from government and industry attended the American Defense Preparedness Association (ADPA) sponsored-conference, which was highlighted by remarks from LTG William Reno, Deputy Chief of Staff for Personnel, Mr. William Clark, Principal Deputy Assistant Secretary of the Army (Manpower and Reserve Affairs), and Mr. Richard Vitali, Technical Director of the US Army Laboratory Command.

Speakers included a variety of government agency and industry representatives. The presentations were divided into four general areas: The Organizational /Management Process, User-Centered Design Advances, Systems Integration Methodologies, and Sources of User-Centered Technology.

LTG Reno opened the conference by assuring participants of his "commitment and interest in MANPRINT" as the program matures into adulthood. He said that the program, both in concept and application, offers methods of dealing with complex problems and "will be a necessary and vital part of any future progress we hope to achieve as we literally 'do more with less.'" In the past, he says, MANPRINT has focused primarily on the objective of improved weapon performance through human engineering integration; and, although that remains a prime objective, there is a challenge from a new direction—that of organizational change. With the Acquisition Corps and other ongoing centralization efforts, law and policy has led to a new and narrow emphasis on acquisition. If we are not careful, acquisition will become a dominant force that could threaten to bypass the needs of the user. MANPRINT and other means must be used to balance the process and to influence acquisition from the users' perspective.

Readiness is MANPRINT's ultimate goal, and we must refrain from becoming too preoccupied with the manpower and training side of MANPRINT to the detriment of treating the entire organization. LTG Reno emphasized that the result we seek is "the smooth performing interface of systems and people—the unit, the organization." He went on to say that MANPRINT must be shored up as a discipline and that we must create forums for educating all Army decision makers on the value and need for MANPRINT and its results."

In summary, LTG Reno said that he expects MANPRINT to "contribute significantly to the readiness of the future Army that we have shaped in concept and are beginning to build in detail." Although the value of MANPRINT should become apparent to everyone as this building process goes forward, LTG Reno is well aware of the difficulty of selling change and new ideas in the Army. With a focus on readiness, he says, we will need "clever, articulate experts to work the issues and inform the leadership." LTG Reno declared that this is a matter of marketing a great product in tough times, and that he intends to be MANPRINT's top salesman.

In his luncheon address, Mr. William Clark reiterated the pride the defense community has felt in the successful outcome of Operation Desert Storm. He said that we must ensure that the next time our troops are engaged in conflict that they will be equally effective, and programs like MANPRINT can give us greater assurance of the quality we seek. Human performance, as an integral part of system design, he says, has experienced great technical progress. While MANPRINT has earned many successes, the program faces trying times ahead with the downsizing and restructuring of the Army, increasing fiscal restraints, and technical difficulties associated with MANPRINT's continued growth.

In Mr. Clark's view, the future holds many challenges for the MANPRINT program. The first is that our unprecedented successes during Operation

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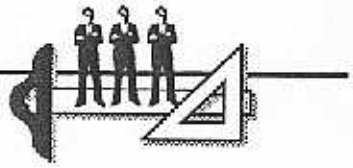
Desert Storm have created have "expectation of excellence" by the government and by the American public. Mediocrity and waste will no longer be tolerated as tax dollars are stretched; and return on investment in new technology must be demonstrated, he says, in terms of performance.The complexity and danger inherent in the modern battlefield makes man-machine integration more critical. This, he says, leaves little tolerance for error, and it is the job of those in weapon system design and development to diminish this potential for error. We must free the battlefield of non-essential elements, simplify the tasks, and "design equipment that makes performing each task easier, faster, and more effective."

Mr. Clark wrapped up his remarks by emphasizing the theme that ran throughout the symposium: that MANPRINT must be institutionalized to the point of becoming transparent so that all of us—not just the MANPRINT specialists--keep the human in mind as a natural part of our business activities. "We must not fail the soldiers and their families, " he declared, "who depend upon us making their equipment the best in the world."

For more information contact Ms. Barbara Frank, HQ DA (DAPE-MR), Washington, DC 20310; (703) 695-9213.

Manpower and Organization Design



Thomas E. Mannle, Jr.
Dynamics Research Corporation (LTC, USAR)

The Army's MANPRINT (Manpower and Personnel Integration) initiative has traditionally been concerned with the manpower impacts of weapon system design, and conversely, with the implications of human performance limits for system designers. This paper outlines a prototype analysis process used to extend this fundamentally sound logic beyond the system level, i.e., to identify the manpower impacts of Army organization design decisions.

In the years ahead, the Army faces tough decisions on key issues: a smaller Army, a reduction in the number of funded weapon system acquisition programs, and the probability that force design initiatives will profoundly change the shape of a smaller force, as traditional roles and missions are re-examined in light of the realities of a changing world.

Manpower is a key thread running through each of these issues. Proposals to redesign the force, or to shift missions and tasks from the active component to the reserves (in some cases, vice versa), or to acquire new systems, will be scored not only by the potential improvements in capability, but also by the manpower spaces required to implement them. The increasing scrutiny being placed by OSD and the Congress on a new system's Manpower Estimate Report (MER) is a good example of the new climate.

The MER poses a particular challenge to the Army. The original Congressional language seems to assume that there is a direct cause-and-effect link between a new system's manpower requirements and a Service's end strength. Because the Army has always stressed unit, not system, warfighting capability and a combined arms orientation, this assumption may be less valid for the Army than the other Services. For the Army, trying to relate the requirements of one new system to end strength impacts is a much more complex endeavor.

The MANPRINT experience in system acquisition has shown that unit focus is an important piece of the manpower equation. The Operational and Organizational (O&O) concept defines the context of a new system's employment on the battlefield, and this definition—via such factors as the OPTEMPO, the maintenance and support concept, and individual productive capacity—is a significant driver of manpower requirements. Despite the importance of these factors in

system acquisition, and the emphasis unit capability receives in the doctrinal literature, the issue of unit design does not enjoy the same level of analytic and management attention as does weapon system design. Rather, unit design is often treated as a "given," an input or assumption for other analyses.

FUNCTIONAL SORT

	STRENGTH	C2 CORE	PRIMARY/PACING	SECONDARY/TENANT	SUPPORT GENERAL	SUPPORT EQUIP	SUPPORT PEOPLE
TANK BN	558 =	28	243	80	18	131	58
	100% =	5%	44%	14%	3%	24%	10%
FA BN	721 =	50	302	165	13	146	45
	100% =	7%	42%	23%	2%	20%	6%
MECH BN	824 =	38	477	77	21	145	66
	100% =	5%	58%	9%	3%	18%	8%

Figure 1.

Recent work by the Army Research Institute (ARI) has addressed one aspect of unit design. In their effort, ARI researchers found that unit design decisions were made by many agencies at different organization levels, usually guided by military judgment and experience, but lacking tools and aids to support unit design decisions. ARI is currently building a family of tools (SORD-Systematic Organization Design) for use in the Table of Organization and Equipment (TO&E) unit design process. Even with SORD, however, two designers operating from different bases of knowledge and experience could design two different units to accomplish the same mission. This is because the Army lacks an explicit theory of organization providing guidance for which forms of organization are to be considered more capable—and hence more valuable—than others.

The analyses described here assumed that the elements of such a theory could be grasped by examining the functional structure of several small units, and comparing and contrasting across unit type to identify similarities and differences. Explanations for why the similarities and differences exist would be the first pieces in the larger puzzle of why the Army chooses to organize its small units as it does.

Three MTOE battalions, all representative of a heavy division structure, were examined—a tank battalion, a mechanized infantry battalion, and an artillery battalion. Using the seven tactical level warfighting functions found in the Blueprint of the Battlefield (TRADOC Pamphlet 11-9), the personnel assets of each battalion were first categorized functionally. The categories were then rearranged and allocated to one of four different functional groups that explained presence or absence in the unit. These four groups were a Command and Control (C2) Core, a Primary or Pacing Function (the one most closely related to the unit's SRC), Secondary and/or Tenant Functions (complementary to the Primary, or present in this unit to support operations elsewhere), and Support (further divided into General, Equipment-related, and People-related). The results of this process are shown in Figure 1.

The remainder of the prototype analysis consisted of developing insights into some specific issues raised by the data table. For example, it appears that the percentage of personnel in the C2 Core is relatively stable across unit types, and that there is a standard "base" of scouts and mortars in maneuver battalions. Other insights tied personnel assets directly to the Air-Land Battle concepts of synchronizations and reconstitutions/recovery.

Initial briefings of the concept and analysis to senior Army manpower and personnel officials indicated that the approach would be pursued further to support manpower/technology trade-off decisions, manpower resource allocation, and unit design studies. The potential to determine the manpower "price" of the features underlying operational concepts was deemed especially important.

Additional briefings of the concept and analysis to other Army leaders are being arranged. For more information, contact Mr. Dennis Collins, HQ DA (DAPE-MR), Washington DC 20310; (703) 695-9213.