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Making Analysis Relevant

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We've all seen this. Most experienced analysts may have experienced the following. The analysis team has just finished briefing the General on the results of their six month study effort. The briefing went well enough. It should have; after all, the model was accredited, the data were validated, and the peer review was rigorous. The General had a few polite, penetrating questions followed by, "Nice job," and "Keep up the good work." The only actionable guidance from the briefing was framed as a question, "Who do you plan to distribute it to?" Deep inside, you know now that despite all the hard work, this study is not going to change the world. It isn't going to have a noticeable impact. There is nothing wrong with it. It's elegant, but it isn't "RELEVANT." Tragically, many analyses, particularly at the top levels of defense decision making, tend toward the category of irrelevancy.

What can make a study irrelevant? There can be many reasons. Most obvious is that it is late; delivering its message after the decisions are made. A study can also be irrelevant if it addresses the wrong questions or if it just doesn't address the central issues. More subtly, a study can be irrelevant if in the end game it just lays there; not offering an action verb in its findings.

To be more relevant a study should be what could be called "actionable." In today's Defense arena, "actionability" tends to come in two flavors; increasing capabilities and/or lowering costs. The Air Force has coined a word for making studies "actionable." They call it "operationalizing" the study.

For example, another study addressing the impact of Weapons of Mass Destruction on theater level operations could tend quickly toward irrelevancy unless it goes far enough to provide insight into what might be done to lessen the impacts and reclaim lost capabilities. Studying how bad things can get can be eye opening and down right motivational. But, unless the study provides "actionable" insights, unless it "operationalizes" the subject, it is just begging the next question, "What can be done about it?" A study's relevancy lies in its ability to motivate action.

Having said that, I need to acknowledge that quite often the role for a study is simply to inform. Sometimes static insight is needed. Insight is a first step to taking effective action. But, the role for such studies is just that, a first step. Too often, the first study may become the format for the follow-on study ("Tell me More"). The analyst needs to be careful here. Doing the same old trick, but with a bigger dog can derail the relevance of the follow on study. The old adage, "Paralysis by Analysis," probably has some roots in this phenomenon. Follow on studies that don't help move the decision makers toward action tend to become irrelevant. The effort put into them becomes a substitute for progress.

So, what can an analyst do to help make a study more relevant?

Maybe the most useful approach is to follow an analytic process, a recipe. Many of the notable analysts who have come before us used such recipes. My favorite is that provided by **John D. (Dave) Robinson**, Maj Gen USA, Ret. when he was the Director for Force Structure, Resources and Assessment, J8. The analysis process was to follow these steps in order:

- What's the question?
- What's the "real" question?
- What do the final slides look like?
- What do I already know?
- How do I get the remaining information I need?

Let's look at the first two steps of the recipe, "What's the Question?" and "What's the Real Question?"

Today, more than ever, the initial question asked of the analyst is probably not well focused. The "real questions" are elusive. They are elusive for a lot of reasons. We don't have a well understood threat. We have a host of new missions to consider. Technology is perturbing our warfighting processes faster that we can characterize them. Basic military organizations and institutions are in flux. Asymmetries abound. The force structure and the budget is a constant question. Jointness seems to pervade everything, yet at times it is diffi-

(See **ANALYSIS,** *p. 33)*

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MORS PRESIDENT

MORS 1997-98: "Keeping Military Operations Research Relevant"

Dr. **Jerry Kotchka**
MORS President

The theme for the 1997-1998 MORS is "Keeping Military Operations Research Relevant." A subtheme that suggests itself is "Keeping MORS relevant." There are two major ongoing keys to keeping our society relevant. These are people and vision. As for people, MORS must have volunteers because MORS is an organization of volunteers. MORS represents well over 2500 professionals.

As described in the "*World of MORS*," our professional activities are managed by a Board of Directors (BOD) of 30 operations research professionals — 28 of which are elected to fill emerging vacancies for a four year term by the existing BOD. It is essential that membership is viewed not as recognition, but as a responsibility to the profession to work hard to accomplish effectively and efficiently, the purpose of MORS and to keep MORS relevant. The BOD strives to insure that it represents the membership both in its makeup and by its actions. First, we strive to insure there are members from all six Sponsors — military and other government operations research analysts, from inside and outside the "Washington beltway," from military offices in the field, and from academia, FFRDCs and industry — all taking actions together to create and achieve a vision for MORS.

In addition to the BOD, MORS is made up of many groups of volunteers — senior advisory groups; advisory directors; non-board committee members; composite and working group chairs, co-chairs and advisors; Past Presidents and Fellows; editors and department editors of MORS publications; and others whom respond to special requests. To repeat, the key to MORS is people — volunteers — who work together to structure the future vision of MORS, to define a Plan of Action and Milestones (POA&M) for the near-term portion of the vision, and to assist in keeping the MORS vision relevant.

The overarching boundaries of the MORS vision is captured in the MORS Goals which identify the purpose of MORS and twelve focus areas for MORS. The MORS Goals are to enhance the quality and usefulness of military operations research. The Society endeavors to:

- Understand and encourage responsiveness to the needs of the user of military operations research.
- Provide opportunities for professional interchange.
- Educate members on new techniques and approaches to analysis.
- Provide peer critique of analyses.
- Inform and advise decision makers on the potential use of military operations research.
- Encourage conduct consistent with high professional and ethical standards.
- Recognize outstanding contributions to military operations research.
- Assist in the accession and development of career analysts.
- Strive for a membership which is representative of the military operations research community.
- Preserve the heritage of military operations research.
- Preserve the role of MORS as a leader in the analytical community.
- Encourage the use of operations research in support of current military operations.

The process for defining, implementing, and adjusting the MORS vision for implementing our MORS Goals is also important. This process is the MORS strategic planning process which is provided oversight by a Strategic Planning Committee that reports to the President.

Each year for the past several years, the MORS BOD has conducted a strategic planning session in June before the annual symposium. The purpose of the meeting was to ensure the BOD remained focused on the future as next year's Executive Council, BOD, and committee members were to be determined in the following few days. As the Strategic Planning Committee chairman, Dr. **Gerry McNichols** (twice MORS BOD member) pointed out a few years ago, the strategic planning process is as important as the strategic plan. In June 1997, the plans of actions and milestones (POA&Ms) of the Executive Council and their committees were reviewed to see how well MORS Goals and other objectives were being achieved. This year the focus was to write POA&Ms early and share with each Director so we could work together and capture emerging opportunities across different committees. Another attempt to influence the future direction and vision of MORS was for your Executive Vice President, **Dick Wiles**, and myself to brief "MORS Directions" to not only our MORS Sponsors, but also leaders and members of FFRDCs and analytical companies that support MORS with their members' sponsored participation. The feedback was useful and the challenges tough, and the feeling emerged that MORS might not always have time to respond efficiently.

Based on this feedback and lessons learned from past Board strategic planning sessions, in December **Ted Smyth** — current chair of the Board Structure and Governance Committee and past chair of the Strategic Planning Committee — proposed that a new volunteer officer position be

(See **MORS PRESIDENT,** *p. 30)*

Upcoming MORS Meetings

Analysis Requirements for the Next QDR – 7, 8, 9 April, The Johns Hopkins University Applied Physics Lab, Laurel, MD

66th MORS Symposium – 23, 24, 25 June 1998, Naval Postgraduate School, Monterey, CA

SIMTECH 2007 Session 2 — Tentatively scheduled for 11-13 August 1998, Location to be determined

1998 — A Year of Accomplishments for MAS

Tom Gulledge
MAS President

As we move into 1998, I am reporting to you that MAS is healthy and all trends are in the right direction. Our finances are in good order, and we have a number of new initiatives that will be realized during 1998. There are many possible topics for this column, but I have selected two for discussion: The MAS National Conference and Military Operations Research at non-military universities.

It has been many years since MAS has hosted a conference. MAS conferences were quite common in the 1980s, but in recent years we have focused almost entirely on the INFORMS National Meetings. In a recent survey, the MAS membership indicated that a MAS conference, independent of the INFORMS National Meetings, was desirable. The idea for a MAS National Conference was proposed by my predecessor (**Steve Balut**), and it is being executed by our Redstone Arsenal Chapter.

The Military Applications Society of the Institute for Operations Research and the Management Sciences will hold its first National Meeting on 19-21 May 1998 on the campus of the University of Alabama in Huntsville. The theme of the meeting is *Going Forward Into The Future With Military Operations Research.* The conference will be hosted by the Redstone Arsenal — Huntsville Military Operations Research Section (RAHMORS) of MAS.

We are soliciting your support for this conference. The MAS Council is proposing an intense transfer of knowledge in an academic setting. Sessions and presentations in the area of contemporary military operations research and management science are solicited. Prospective participants and attendees may contact either the General Chair, **Anthony Brinkley**, Teledyne Brown Engineering, Huntsville, AL [tony_brinkley@pobox.tbe.com], or the Program Chair, **Bruce Fowler**, US Army Aviation Missile Command, ATTN: AMSAM-RD-AS, Redstone Arsenal, AL 35898 [fowler-bw@redstone.army.mil or (205) 876-8173].

Our membership also indicated by survey that participation in a single INFORMS National Meeting per year was desirable. In response to this desire MAS has not organized a full program for the 26-29 April National Meeting in Montreal. However, MAS has organized several panel discussions, and the MAS Council will be conducting business at the meeting. Also, there will be Military Operations Research sessions at this meeting. These sessions were organized as part of the invited conference program by **Kevin Ng**, a long-term MAS member and distinguished Canadian colleague. Information about these sessions may be obtained directly from Kevin [kevinng@dms-hp.ora.dnd.ca]. I look forward to seeing you in Montreal, and I invite all current MAS member and interested colleagues to our business meeting and reception, which will be held on the Monday evening of the conference.

My second topic for this column is Military Operations Research in non-military universities. I use the term non-military because all of our service academies and military graduate schools have integrated Military Operations Research throughout their curricula. These schools continue to produce the practitioners and leaders of our profession. There are "pockets" of Military Operations Research at other universities, but I am not aware of any new programs that have appeared in recent years. I am happy to report that a new program is imminent.

As a direct outgrowth of a MORS Educational Colloquium, George Mason University in Fairfax, Virginia, has designed and is implementing a new curriculum in Military Operations Research. The Masters-level curriculum will be implemented in the Department of Operations Research and Engineering within the School of Information Technology and Engineering. The degree offers a number of elective options, but the foundation is centered around two core courses: MOR Effectiveness Analysis and MOR Cost Analysis. The curriculum is currently being reviewed by senior members of MAS and MORS, and the first students will be admitted in the Fall of 1998. Details of the program may be obtained from Prof. **Karla Hoffman** [khoffman@vms1.gmu.edu], the Chair of the Department of Operations Research and Engineering.

I run the risk of being accused of advertising for George Mason University, but that is not the point of my column. The point is that our efforts in trying to influence educational institutions to meet the needs of our profession are achieving results. The efforts initiated by **Yupo Chan** and **Kenneth Konwin** kindled the idea and had an impact on the George Mason University decision to develop its Military Operations Research curriculum. I commend Yupo and Kenneth for all of their hard work on the MORS Education Committee. The students are our future, and a continued focus on the primary input (i.e., students) will assure quality output (practitioners and leaders).

I am interested in reporting other developments relating to Military Operations Research education. I welcome your input on these issues. As usual, feel free to contact me by Internet [gulledge@gmu.edu]. The MAS Council continually monitors the MAS Listserver, and you can always contact us or the membership by this means. If you are not already a member of the list, you can subscribe by sending the following message to majordomo@mat.gsia.cmu.edu:

subscribe mas Your Name, Title
< yourname@domain.org>

If you have problems, send a note to **Philipp Djang**. He doubles as the moderator of the list. I will use the listserver to provide information of interest to the Military Operations Research community as it is passed to me. I encourage you to do the same. ✪

Preparing the Military Operations Research Society for the 21st Century

CAPT **Lee Dick**
Secretary

To paraphrase the theme for the 66th Military Operations Research Society Symposium, as we approach the year 2000, it is also a good time to take stock as to where the future of the Society lies. Certainly, the catalyst for any robust organization is an active, vibrant, involved membership, which accepts the organization's vision and actively supports the goals and objectives to achieve that vision. In MORS we have such a membership. It's not just a few pulling their weight, but the active involvement of so many which has been, and will continue to be, the key to the survival and continued growth of our organization.

The challenge for MORS leadership — as we turn the century — is to keep that momentum going. We have built a reputation as a world class organization which quickly reacts and provides quality products to our Sponsors' needs. Our annual Symposium has covered the full spectrum of analysis thanks to the hardworking and dedicated efforts of the members who have served in the capacity of Composite/Working Group (CG/WG) leaders. Even more important, however, is the vital contribution of all those who have supported the Society in making their presentations at the MORS Symposium, for this is the entree — the food that provides the nourishment for our Society.

Our meeting operations do not suffer from a lack of topics for Mini-Symposia and Workshops; in fact, the challenge facing us on the Board is limiting the number of meetings within our Charter in the near future. Our publications, the *PHALANX* and the *MOR* journal, continue to be filled with quality, relevant articles. We always have an abundance of well deserving Board of Director candidates who have surfaced from the membership mass. And most recently, the membership committee under the leadership of LCDR **Katie Thurman** assembled an outstanding slate of nominations, from which the Board selected our newest MORS Fellows: DR **Jacqueline Henningsen**, FS, Chris **Fossett**, FS, and **Vern Bettencourt**, FS. While congratulations are in order for the new inductees into that august, revered elite — a hearty well done is due to the membership committee who did such an outstanding job in identifying a candidate list with such high qualifications and credentials.

What are the nutrients that will keep our organization strong? How can we keep the membership base rejuvenated across the many analytical fronts, so that the best analytical efforts continue to be brought to the forefront and highlighted? Perhaps those answers can be found in the new sciences. We recently have focused on the application of the new sciences to analysis, or vice versa, but what if we applied some of those concepts to our organization itself?

Let's then examine some of the life sustaining ingredients, which will continue to cause the Society to grow. Specifically, if we treat our organization as a natural chaotic process that continues to reshape and revitalize itself, three key organizational areas emerge — namely information, relationships, and vision.

Information — the Lifeblood

Information has been characterized in the new sciences as the 'lifeblood' of an organization. It is the energy source, which in fact enables the organization to live and produce. It is what generates activity within the organization, the life resource that allows the processes of renewal and revitalization to occur. In our Society, it may be the sharing of a relevant piece of analysis, the publication or presentation of analytic techniques, the formulation of analytical approaches, or the sharing and exchange of ideas at Symposia and Workshops. Information *is* the *PHALANX*, the *MOR* journal, the presentations at MORSS, the proceedings of our workshops, and the various literature published by our membership.

Relationships — the Distribution Foundation

Relationships are not the building blocks of our organization, but are more like a circulatory system. They are the manner in which information is distributed and shared within our Society, the key conduits across all segments within and external to our organization. They are the Composite/Working Groups, the subgroups of workshops, the Senior Advisory Groups, the Prize paper process, the committees of our Board, as well as our website and e-mail distribution system.

It is also how we interact externally to other organizations and societies, such as MAS and INFORMS. At the summer 1997 Board Meetings, we formed a new committee to examine our relationships and how we liaison with other organizations. The committee has recently been examining policy and guidance on how to enter business agreements with such organizations.

We have made significant strides in the area of 'virtual' relationships the past couple of years — with the establishment of a website that at first was not much more than a ceremonial electronic glossy advertisement. Our electronic media committee, currently led by **Glen Johnson,** and the MORS staff has continued to expand the utility of the web to the point that it has become a vital and accepted tool. Current information is displayed pertaining to forthcoming MORS events — the invitation letter, terms of reference (TOR), application forms, and meeting Read-Aheads — proceedings of completed workshops, and our Monthly Activity Reports (MAR). It will no doubt continue to grow and react to change, to provide the means to get timely,

(See **VEEPS PEEP,** *p. 30)*

Some Comments on the State of Operations Analysis

Senior Lecturer **Wayne P. Hughes**, Jr., FS
Naval Postgraduate School

Professor **Wayne P. Hughes**

An extraordinary metamorphosis is underway in Operations Analysis (OA) that reaches well outside our profession and is wrapped up in questions about its proper boundary. Higher education everywhere is threatened with a massive transformation, as old disciplines such as physics, chemistry, mathematics, biology, and what could be called classical engineering are confronted by new subject matter that is in great demand but is so interdisciplinary that the traditional academic departments have difficulty organizing and teaching it, for instance computer technology, information technology, systems engineering and command and control. New subject matter threatens the old order because it is seen outside of academia to be where the future lies.

What we think of now as interdisciplinary studies may become new or transcendent academic disciplines or professions.[1] At least one, Command and Control (C^2) (to include communications), is probably now sufficiently structured to acquire the characteristics of an academic discipline. C^2 is a burgeoning technical subject extending outside the boundaries of leadership and management. Its military roots are rapidly spreading into the world of business and commerce. More difficult to assess is that hodge-podge called computer science, which as a practical field of endeavor seems to spawn offspring even while it remains marginally accepted as a respectable academic discipline. These are treacherous waters. Even though I hold OA up as an exemplar of a successful new academic discipline that first arose after World War II at the Naval Postgraduate School and Case Institute, there are traditionalists in academia who still gag at expressing OA and discipline in the same breath. Many universities deliver the core material of OA under other rubrics such as industrial engineering and management science, while the US Naval Academy teaches OA in its Department of Mathematics.

Indeed, it is hard to know the boundaries of contemporary Operations Analysis. For instance, does OA include Information Technology (IT), or is IT a new field that embraces many of OA's techniques? Modern OA leans so heavily on IT and computer science that differentiating among them is contentious in the academic world. Almost certainly the impact and influence of IT, broadly construed, already exceeds my OA profession's effects. The reason for this is that every activity (i.e., thought process and operation) starts with an information input. Every activity. One might suppose that whoever controls the information controls the world, except that the usual goal of IT has been for no one to control and everyone to share.

The problem can be traced to the concept of "model." Operations Analysis invented the term, even though dynamic representations of phenomena such as Newton' laws of motion existed long before they were called models of reality. Now models are embraced by nearly everyone, and modeling is done in many places for many purposes that are unquestionably outside of OA, CADCAM and computer artwork, for instance. Too many analysts have come explicitly or implicitly to regard Operations Analysis as the art and science of building realistic models that aspire to be more and more representative of the phenomena they describe, with only passing regard for the utility and efficiency of their representations in helping decision makers. This is a big problem. In my view, OA must surrender proprietorship of modeling as our thing. OA's uniqueness and value lie elsewhere.

So what can we say about the nature of OA and its contribution to society? My visits to Singapore's military and educational institutions has given me some contrasting viewpoints and helped to clarify where we in the military OA profession are headed, and tentatively, how to describe our future directions and contributions.

At the most general level, the purpose of all OA is to help people think and act more wisely. But this general aim also applies to all education, to doctrine, and to plans and operations of all descriptions. The central purpose of OA is to help decision makers make better immediate choices of plans and actions. Of course OA now extends its influence well outside military operations, but that is not where my practical or academic experience lies. I have pondered the question as it pertains to *military* planning and operations, so that is what I will discuss, while adding that these interpretations are probably generalizable to commercial affairs. Regarding the role of OA models, *Military Modeling for Decision Making*[1] says:

> "In operations research, the goodness of a model is judged by how well it achieves its purpose. This is no casually selected criterion. Operations research, whether military or otherwise, is an applied science more akin to engineering and economics than to fluid mechanics or psychology. In the physical sciences a model is usually judged on the basis of, first, how truly it portrays the phenomenon it represents, and second, its range of applicability. Operations research exists to support better decisions. This is not the same thing as a search for truth, which is a good bit harder. Many times our standard of goodness is dissatisfyingly vague — who would not prefer an image of universality such as, say, the laws of motion? In our field of operations research we will have unkind things to say about "universal" models which try to serve too many purposes."

The essence of Operations Analysis is associated with decision making, not model building. Thus, we can exclude two very large arenas supported by modeling:

1. *Education and training devices, systems, and activities*, including training simulators, instructional systems development, and instrumented ranges used for training.
2. *Information technology systems and activities,* embracing information war-

fare (or conflict), information operations, and the Communications of Command and Control (C^3). IT deals with the acquisition, transfer, fusion, display, and dissemination of information.

Properly construed, IT is decision neutral, for when it incorporates a decision support system it invades the domain of OA. When IT specialists dabble in decision making algorithms they are likely to bring trouble, because all except the most routine and mindless decision making involves skills outside the purview of most experts in IT system design.

Part of the problem stems from shared use and ambiguity. Instrumented ranges are employed for controlled experiments as well as training. War games are used both to test new tactics and teach them. Information display systems can usefully incorporate a decision support system, especially when such a system is a mere network of remotely located displays for decision makers, as opposed to a decision aid which helps to analyze the consequences of a future decision. In Singapore, some new computer based systems that gather, process, and display information also incorporate decision algorithms. At the very least, the information is displayed for operators who make their own decisions based on the information presented. The power of the system is achieved when the decision is instantly relayed to other decision makers at other terminals tied into the network, and when aggregated results are displayed up the line. Anyone who books airline reservations will immediately recognize this as a description of his or her network. Indeed, the blend of information technology with widely decentralized decision-making now dominates transport operations of every description.

What, then is the domain of military OA? What kinds of decisions does it support? One at least ought to summarize them to indicate military OA's sweeping applications, even after excluding training and information technology from its domain. A robust categorization is found in *Military Modeling for Decision Making.*[2] In order to distinguish the differing characteristics of the analysis involved, the monograph lists these applications:

- *Battle Planning.* Preparation for wartime operations, based on friendly and enemy orders of battle, and the existing strategic or tactical environment;
- *Wartime Operations.* The conduct of war. Distinguished from battle planning by available, current, wartime data and known, immediate military objectives;
- *Weapon Procurement.* The selection from among competing weapon systems or characteristics for procurement decisions;
- *Force Sizing.* The decision of how many weapons systems of which types to (1) operate, (2) support, and (3) procure in the future, either in the defense establishment as a whole or in a major component such as the army or the nuclear weapons arsenal;
- *Human Resource Planning.* The design and operation of manpower, personnel, training, and assignment systems;
- *Logistics Planning.* The design and operation of all manner of military logistic support; and
- *National Policy Analysis.* Supra military actions that influence or are influenced by military considerations such as arms treaties or subsidies of commercial transportation.

All of these applications, but most obviously human resource and logistics planning, depend on prompt information acquisition and display, and therefore are enhanced by information technology. Nevertheless it is well to keep a clear distinction between IT and OA. When an IT system displays sufficient information for a decision at a terminal, then an operator can take an appropriate action. When the decision is immediately transmitted to every operator in a network and when the information is aggregated in useful ways for high level managers, then the system is valuable almost beyond exaggeration, yet without any OA whatsoever having been performed. I have mentioned booking airline reservations to show what IT has achieved for scheduling. The same value of information technology applies to the transfer of funds, stocks, bonds, and futures in what with the aid of IT has become a worldwide network of financial information exchange. Aggregations of information, such as the Dow Jones Averages and current values of mutual funds are computed and displayed almost continuously.

These IT functions do not make OA-type decisions. OA enters when airline bookings lead to a carefully analyzed change of flight schedules and prices in the face of competition and likely future customer demand. OA occurs when it helps an investor makes his decision based on not merely the latest stock quotation but also on an appraisal of economic conditions and a personal investment policy. It is here that the IT expert in computer programming would do well to pause before he builds a decision-making algorithm into his system. The algorithm is in the domain of OA, and if not done with considerable skill it will be counterproductive. The interface is doubtless a fuzzy one, which apparently is why Singapore labels the development of information systems with decision making features "systems engineering." I think this is a felicitous term for the function, but I wish you to recognize that systems engineering blends together two disciplines or skills, IT and OA.

I hope my profession (and academic discipline if such it is) will see the impossibility of claiming information technology as its own. Our reward is from aiding better decisions, most especially those that exceed routine operations but which are sensitive, immediate, often urgent, and of a unique and singular nature. Understanding the role of OA will dampen our ardor for bigger and more comprehensive models, for the core value of OA does not lie in model building but in helping with better decisions. The best way to think of an operations analyst is as an *alter ego* to the decision maker who serves him with disciplined, objective, time-consuming thought that the decision maker could do for himself if only he had the time. We are also somewhat like Jiminy Cricket on the shoulder of Pinocchio serving as his conscience, at least to the extent of promoting objectivity as the best long-term policy. Information technology cannot make that claim, for its special role is as the eyes and ears, and sometimes the voice, of the decision maker. Neither education nor doctrine can make that claim, for they are not on Pinocchio's shoulder, but like Gepetto are removed in time and space from the scene of action, and must impart more general wisdom.

But the important thing and the hard part is not in setting up domains in which training, doctrine, information technology, and Operations Analysis play separate roles. That is the weakness of contemporary academic departments at most universities. The hard part is to solve highly

(See **COMMENTS,** *p. 20)*

Gotterdämmerung for Military OR Education

David L. Bitters
US Army
Command and
General Staff
College

The *MOR Forum* was conceived in irreverence, as a sort of op-ed page where scholars and practitioners of Military Operations Research could offer candid opinions and judgments on the professional issues of the day. The aim implied, of course, is to provoke thoughtful and reflective dialogue, and thus promote the intellectual health and growth of the discipline. The piece appearing here, by Dr. Dave Bitters of USACGSC, goes to the core of this objective, by examining the nexus between MOR and the larger body of military leadership it serves. To what extent does the contemporary military leader *need* exposure to analytical tools and techniques to:

- Conduct systematic military planning and operations?
- Attack problems in a structured, methodical way?
- Interpret critically the results of rigorous analysis imbedded in complex processes like resource allocation, force planning, weapons modernization, and the like?

Grave questions, to be sure, and the trends evidenced in Bitters' account may alarm some. He raises an important collateral question, too, about the projected availability of focused military education for analysts themselves on complex military applications. This is the other side of the same coin denominating how tight the seam between military operations and Military Operations *Research*. The issue, in short, is *relevance*. Keep those cards and letters coming.

— Dorn Crawford

Franz Kafka's surreal tale *The Metamorphosis* begins with Gregor Samsa, the protagonist, awakening one morning after a bad dream to find himself turned into a large beetle. Lying on his hardshelled back with his small legs pointing upward, he's unable to turn over or lift himself off his bed. Worse, he's locked the door to his room, so none of his family can get to him. He frets that in this unfortunate state he'll be unable to dress himself in time to catch the 7:00 train to work. This will result in all sorts of unpleasantness. Indeed he's soon visited by his firm's head clerk, who demands a reason for his tardiness. He pleads that he views punctuality as a solemn obligation but begs to be excused, just this once, due to circumstances beyond his control. He explains that it won't happen again, that he's sure he can get himself together in time to catch the 8:00 train — and please give his respects to the Chief. Of course, the clerk hears nothing but gibberish.

I thought of this story when my employer offered me the opportunity to change occupations.

A little background would be in order. From 1981 until the summer of 1996 I was a full-time instructor of operations research/management science-related courses at the US Army Command and General Staff College. The College's continuing interest in my services flowed primarily from my involvement with a course called *Resource Planning and Allocation.* This was an amalgam of basic OR/MS concepts (decision analysis, probability and statistics, linear regression, economic analysis, Program Evaluation Review Technique/Critical Path Method (PERT/CPM)), and some material on force development and financial management. During a decade and a half I taught the OR/MS portion to more than 3500 officers.

Though it was a bitter pill for some to swallow, most students gave this course favorable reviews. While 30 percent or so admitted to being "mathematically challenged," most seemed to enjoy the rigor and the prospect that if they followed the rules they could get the right answers. A typical end-of-course comment read something like this: "I worked my tail off. But it was worth it and I learned something." Of course there always were some who asserted, "I'll never use this stuff."

I also taught several specialty courses to smaller, self-selecting audiences. These included *Topics in Operational Decision making* and a two-term sequence called *Military Operations Research.* The College calls itself the senior school for tactics in the Amy, so I made a conscious effort to align the content of these courses with this focus.

Most US Army officers lack the mathematical background that their counterparts in the former Soviet Union apparently had. Moreover, those who do have mathematical training often forget much of it during their field tours. Few know anything about specialized topics such as Z-transforms for probability modeling. So the first part of *Military Operations Research* amounted to a calculus and probability refresher. It looked like an engineering mathematics course, without apparent relevance to military problems. Without it, though, the models in the second course would have been inaccessible to most students. This made it necessary to omit a number of otherwise interesting and relevant modeling topics.

The contents of the second part of *Military Operations Research* included dispersion, vulnerability and lethality models, multiple and area target models, sortie models, stochastic duel models and force-on-force attrition models.

These models tell a story. They give insights into how to operate the system, and expose problems and issues. While the validity of some of them in the modern context is a matter of on-going discussion, they provide a source of hypotheses to test and a framework for structuring thinking about tactical problems.

Enrollment in the specialized courses was fairly constant until about four years ago, when the College began to mandate certain branch-specific "electives." Courses not on the short list (mine included) experienced noticeable drops in enrollment.

Early in 1996 the contents of *Resource Planning and Allocation* came under serious review. Some had expressed concern that certain topics of general interest weren't receiving enough instructional

emphasis. As the Command and General Staff Officers' Course (CGSOC) common curriculum at best involves a zero-sum game in terms of instructional hours, the quantitative methods hours became a coveted prize.

Shortly before College management moved to drop these, a Training and Doctrine Command (TRADOC) senior officer briefed the faculty on certain aspects of a new concept called Army XXI. With the enthusiasm of one used to directing (but not necessarily doing) big projects, he offered that "winning the information war" would be fraught with new challenges, as the Army ventured into the complexities of traffic management in communications networks.

I listened in vain during this talk for evidence of even rudimentary understanding of queuing theory and/or network modeling, technologies that have been around for at least thirty years. I also found myself scratching my head in bewilderment; concurrently the College was debating cutting the instruction on network modeling, among other things.

Ft. Leavenworth hosted the MORSS conference in 1996. I looked forward to participating in it fully. However, shortly before the end of the academic year I learned that *Resource Planning and Allocation* was dead. So during MORSS week I found myself attending a training course on force management. This was to prepare me to teach the replacement course: *Resource Planning and Force Management.* I approached this viewgraph-rich experience with vigor, if not with complete comprehension. Meanwhile, I sandwiched attendance at MORSS sessions into my schedule whenever possible.

Several weeks later management informed me the College had abolished my teaching job. No need for an operations research instructor when there's no operations research instruction.

It was at this point that I thought of Gregor Samsa.

You might ask, Who cares? Lots of people have been "downsized." The Cold War's over; the government's going through a contraction; operations researchers (and teachers of operations research) are as dispensable as anyone else. Life's tough. We cope and move on.

Still, while recognizing the dangers of generalizing from a small sample size, I submit that there's a cautionary tale buried in my experience.

(1) Since the Vietnam era, operations research methodology has been embedded in the Army culture. *Every* Command and General Staff College (CGSC) graduate (whether of the resident course or one of the correspondence programs) got approximately twenty contact hours (or equivalent) of instruction in quantitative methods. You could expect mid-grade Army officers working for or with you to have at least a rudimentary technical understanding of the phrase *to optimize.* They would appreciate that often the most challenging decision problems involve *multiple* criteria. They would understand what it means to talk about a *good decision* with a *bad outcome.* They would know that estimation based on averages might lead to underestimation for planning purposes. At one time in their lives they would have demonstrated proficiency in constructing and solving a PERT/CPM network. Sometime after the millennium senior commanders will find that people on their staffs no longer know these things.

(2) The operations research methods we taught to the mid-level leadership involved no mathematical skills beyond *simple* algebra. Bright high-school students could have mastered the mechanics. The value of the OR methodology is its rigorous, structured approach to problem formulation and solution. As most people who have done "real" OR recognize, you're often 80 percent of the way to the solution of a problem, once you've defined it sufficiently to formulate a model. By dropping the quantitative methods instruction from the CGSC curriculum, we can no longer be sure that our mid-grade officers have the "thinking skills" this discipline provided.

(3) My college ROTC program thirty-five years ago had the title *Military Science and Tactics.* Today, I hear almost no one at CGSC speak of military *science.* However, I often hear phrases such as military art and operational art. Has the Army abandoned the notion that the rigors of the scientific method apply to its business? Is it a waste of time to teach the systems approach to operators of the system? If so, organizations such as MORS would do well to rethink their charters. If, on the other hand, there *is* a military science, it isn't percolating into the schoolhouse very well.

(4) Likewise, people in the tactics and leadership departments speak of the *art of command. Is* this something real that can be communicated and for which one can be apprenticed? This remains to be seen. Last summer I did extensive statistical analysis on a data set derived from battles conducted at the National Training Center. Recognizing the ambiguities hidden in the raw data, I wanted to see if any variant of the Lanchester models proposed by anyone during the past forty years provided a reasonable fit. With the opposing force (OPFOR), red force, data I did find a pattern. With the blue force data *the casualties appeared to bear no discernible relationship* to the starting size of the OPFOR, the blue force, or any combination or multiple thereof. How do we explain this? Is it because our commanders are inadequately prepared to do their job? Is it because they all do it differently, with unpredictable skill? I don't know, but my study raises interesting questions about the *art* of command.

(5) There exists a body of scholarly literature under the rubric of Military Operations research. Here I have in mind the various combat models. Few institutions of higher learning offer instruction in this technology, and their numbers are shrinking (the Air Force Institute of Technology, for instance, will soon close its doors). While I spend most of my time in academic administration now, I did offer the *Military Operations Research* sequence at CGSC last spring. Only one student enrolled in *Military Operations Research II,* the models course. So, while this sequence isn't dead yet, it's clearly comatose. My guess is that, like General MacArthur's Old Soldier, it will just fade away. This seems strange, since the concepts that form its contents are embedded in many of the models and simulations the Army depends on in the development, procurement and decision cycles (Kafka's tale comes to mind again).

People at higher levels than I who are paid more than I make the tough choices concerning budget allocation and course content. I won't try to second-guess them. But I do think the MORS community should be aware of what they've done, and begin preparing for the likely consequences. ✪

Quick Response Simulation: Laughlin AFB Capacity Analysis

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Introduction

Current software accessibility dramatically reduces the time and effort required to develop, validate, and visualize models supporting managerial decisions. Much of the simulation literature focuses on spreadsheet applications for quick-turn probabilistic analyses; however, with modern tools and techniques, discrete-event simulation software can now be used for projects that must be completed in minimum time.

The authors recently were involved in such a short-term project. The leadership at Laughlin Air Force Base, an undergraduate pilot training base in Del Rio, Texas, saw the writing on the wall regarding dramatic increases in pilot production and wanted a quick analysis of their airfield's capacity. Specifically, the Laughlin leadership was not sure that the 47th Flying Training Wing could meet the training requirements projected by headquarters for the next five years. The Air Force needed more pilots, and they needed them in a hurry. Plans were being formulated to increase output for Undergraduate Pilot Training (UPT). While increased student load would normally be welcomed, for the remaining three UPT bases (dwindled from five in 1983) the increased demand appeared to exceed their physical capacity. Unfortunately, the deterministic spreadsheet planning model employed to determine maximum enrollments did not capture the important limiting effect of variation. The authors were sent to Laughlin AFB to develop a more realistic model of the maximum sortie capacity at Laughlin.

Background

The United States Air Force trains hundreds of pilots every year and the management of this force is one of the greatest personnel problems faced by the Air Force leadership. Market forces continually change the demand for pilots in the airline industry. During hiring booms, the major airlines will hire over 300 pilots per month, most of them military. Additionally, the unpredictable government budget cycle means that predicting the need for pilots is notoriously difficult. In times of national crisis or a pro-defense administration, the need is great. In times of stability and peace, the defense budget cuts dig deepest into education and training programs.

Military downsizing efforts after the end of the Cold War reduced the Air Force pilot production to approximately 500 pilots per year in 1994 and 1995 (see Figure 1). In addition to the drawdown, the airline industry was in a recession and hiring was nil at the major airlines. As a result, most pilots (70-80%) were accepting a pilot bonus and agreeing to stay in the Air Force through 14 years of service at the end of their initial training commitment (see Figure 2).

During this period the Air Force enjoyed excess capacity at its pilot training bases, which prompted the Base Realignment and Closure Commission to list UPT bases at the top of their closure lists. Williams AFB had already closed, then Reese AFB was added to the closure list in 1993. Thus, 40% of the UPT capacity was eliminated in rapid succession (Sheppard AFB, a joint NATO-US training base, also remained open).

Shortly after Reese was added to the closure list, the Air Force began to realize a problematic trend; pilots were leaving the Air Force at an alarming rate. The major airlines had begun hiring in large numbers, and the production pipeline had been producing a fraction of the pilots needed. The pilot bonus acceptance rate plunged from over 70% in 1994 to approximately 30% in 1997. Given these conditions, the Air Force planned to increase the UPT production to 1100 pilots per year by 1999, more than twice the number produced in 1994 and 1995.

Previous Studies

Could the remaining three UPT bases sustain 1100 graduates? Keep in mind that the current 15% student attrition rate requires that T-37 schedulers plan for nearly 1300 pilot candidates. Headquarters' planners felt that this production level was feasible. Analysts projected that a production rate of 1100 pilots per year equated to

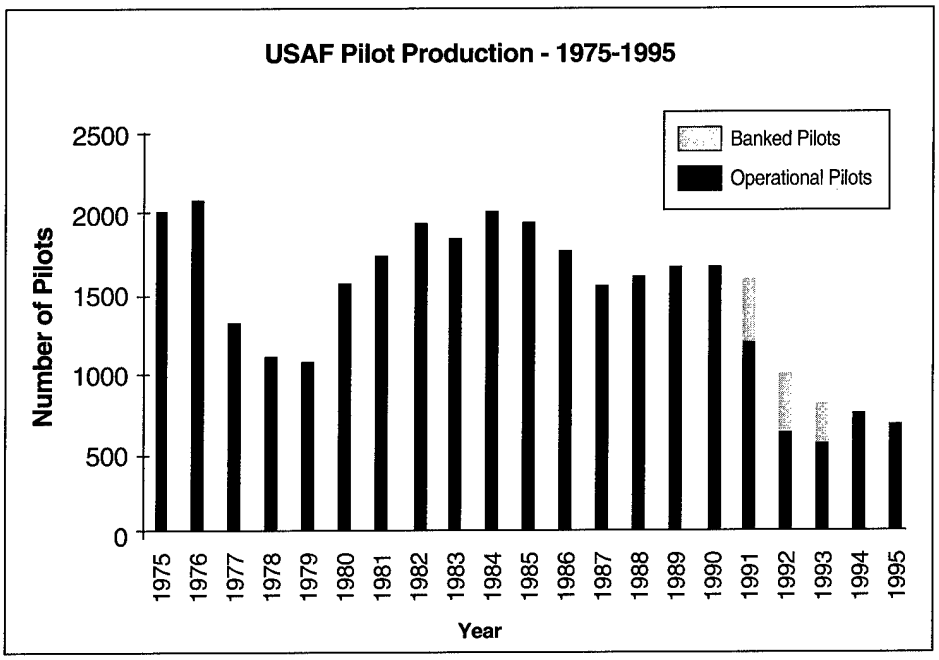

Figure 1

Source: Air Force Personnel Center

92% of overall capacity. Laughlin planners wondered whether the maximum capacity estimates were realistic. This level of performance would be the highest operations tempo for UPT bases since the Vietnam era, even higher than the Reagan build-up of the mid-80s. In addition, the maximum capacity estimates were derived from simulations run during the 1970's. At that time, only two aircraft (T-37 and T-38) were involved in training pilots. Many factors had changed in 20 years, such as environmentally-friendly airspace restrictions and the implementation of the Specialized Undergraduate Pilot Training (SUPT) program. The Air Force now relies upon three aircraft (T-37, T-38 and T-1) to train its pilots. The addition of the T-1A Jayhawk trainer added a new dynamic to the air operations while creating additional infrastructure requirements. Further, during this production build-up the Air Force must transition into an entirely new trainer platform as the Joint Primary Aircraft Trainer System (JPATS) replaces the T-37.

The existing training capacity model was a spreadsheet program based upon many variables, including weather attrition, maintenance attrition, and miscellaneous attrition for such factors as pilot illness and scheduling difficulties. The historical data for these factors was thorough and stable. However, one important assumption of the model specifies that aircraft takeoff every 2.5 minutes. Thus, the maximum capacity was based upon an assumption that had not been tested operationally within the current SUPT training syllabus. Obviously sustained capacity was highly sensitive to this number. For example, during a twelve-hour day, a takeoff every 2.5 minutes would generate 288 training sorties, while a takeoff every 3 minutes would generate 240 sorties, a difference of approximately 20%.

Laughlin's Predicament

Initially, Air Education Training Command (AETC) projected a gradual increase in pilot production to about 900 pilots annually by 2001. Although this would be a large increase, the Laughlin leadership felt that this production level was manageable. However in late 1996, airline hiring increased and the pilot bonus acceptance rate plummeted to less than 30%. The Air Force would have to replace even more pilots than previously planned. AETC raised the planned production numbers to 1100 pilots annually by 1999. Laughlin's leadership felt that this number might not be feasible under the current methods of operation. However to verify their intuition, they desired an objective analysis of the maximum capacity given airspace, area locations, runway configurations and pattern restrictions. The Laughlin leadership was not interested in sortie scheduling, maintenance schedules, aircraft or crew availability, attrition rates, weather factors (other than daylight hours), or any limiting factors that could be resolved with additional funds. The focus was to determine the absolute upper limit given perfect external conditions and little change to the operational structure.

Realizing that this project required external expertise, a former faculty member from the Air Force Academy called the USAFA Department of Management for help. The Department constructed a consulting team that consisted of a team leader with problem framing and modeling expertise from the Management department, a Computer Science faculty member with modeling and simulation expertise, a Management instructor with subject matter expertise (recent AETC T-38 instructor pilot), and a recent Operations Research graduate. The team was established quickly and began work to resolve this complex issue almost immediately.

As initially presented to the consulting team, the problem was "simple"; calculate the capacity of the base and have a report ready within 30 days. Our team quickly realized a problem that our USAFA students often complain about: time. We did not have time to provide a full solution within the timeframe requested. Fortunately, Laughlin personnel were gracious and agreed to explain the problem and await our assessment.

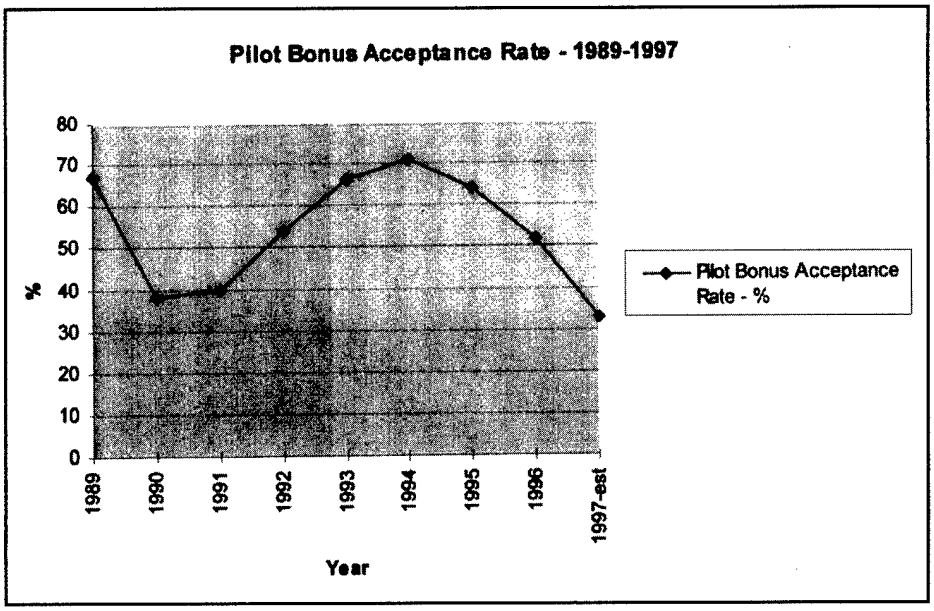

Figure 2

Source: Air Force Personnel Center

Narrowing the Scope

The team's first priority was to understand daily operations. This required a quick trip to Laughlin AFB. Since Randolph AFB in San Antonio (home of Headquarters, AETC) is on the way to Laughlin, a side trip to Randolph AFB to visit with AETC's resident sortie rate expert was in order. The team walked the flightline, sat in the air traffic control tower, talked with schedulers, and witnessed students from briefing to debriefing. These on-site observations helped frame the problem and visualize some of the key issues. The team quickly realized the magnitude of this difficult task. In order to meet the time restrictions for this project, it was necessary to limit the scope of the analysis. Laughlin leadership agreed that a complete model of limited scope was more valuable than an incomplete attempt at a comprehensive model.

(See **QUICK RESPONSE,** *p. 31)*

A Cybernetic Explanation of the Paradigm Shift in the Praxis of Complex Dynamics in the Combat Simulation Environment: The Case of Joint Warfare System (JWARS)

Dr. **Oliver Hedgepeth,** GRCI

Introduction

Operations research (OR), development of combat Models and Simulations (M&S) and methods of analyzing the complexity of the simulated battlefield have undergone a paradigm shift over the last 30 years. Currently, the M&S community is embarking on a new paradigm of M&S analytical development called JWARS. It is felt that JWARS will be the first of a new paradigm of analytic models that can better address the complex warfight issues of the OR and M&S community.

The objective of this cybernetic exploration of the environment of complexity within the combat simulation, and the exploration of the complexity analysis within the Military OR community is to outline a strategy for understanding the paradigm shift that has occurred. This shift, as evidenced by symposia like MORSS, indicate a new paradigm in the praxis of working in the OR environment. The implications for the future of military OR will be told in the applications of the new class of simulations such as JWARS.

The Paradigm Shift of OR

Since World War II, the paradigm of OR has focused on optimization, and as computer technology became more of a common tool, the development of combat models and simulations followed this paradigm. Limitations of computer technology and the growing use of OR tools contributed to better understanding of various optimization tools and techniques.

The OR method used the reductionist method when analyzing weapon systems, tactics and doctrine. And, the charm for us was always success for the systems analyst, computer programmer, and the decision makers who had a measure of effectiveness to help them choose which alternative weapon system to purchase.

But, consider the Military OR community as a closed system. When it started it had variety. The OR community was composed of different scientists, civilian and military thinkers, historians, academics and lay persons. It started as disjoint incrementalism. This variety provided a success factor in the early days of military OR that could be attributed to problem solving skills from that wide variety of mixed-disciplined teams, as well as a sound understanding of the practical issues to be addressed obtained from user experience.

Over the last 30 years that variety has slowly decreased due to focused training in the "science" of OR. This decreased variety was seen by some as limiting the ability of the OR community to conduct complex warfare analysis.

Since the 1960's the discipline of Military OR, assisted by the growth of computer technology, developed a foundation or legacy of combat models and simulations that allowed the operations researcher to better understand the limitations within the realm of modeling real world events. The number of models and simulations grew from a handful to hundreds.

In the 1980's the Department of Defense embarked on a bold approach to bring Artificial Intelligence (AI) applications into decision making, OR, data management, combat service support and combat simulations. Add to this AI push (and credit is given to the insights of GEN **Max Thurman**), the creation of the Army Model Improvement Program, the collapse of the Soviet Union and the end of the Cold War, and the entire concept of Military OR was beginning to be reexamined from within and without. However, the paradigm of OR was not easy to change.

A concept was that AI would bring the simulations closer to this battle truth by addressing that troublesome error term. That push into AI did not succeed in replacing the error term. It did provide us with the metaphors that brought the Military OR community to where it is today. And, while many may see that AI push as a failure to deliver certain products, perhaps the key legacy was the new language and metaphors that we use today that allow us to have a more open, less reductionist, approach to problem solving — using combat simulations.

In 1992, a warning was issued from the Deputy Under Secretary of the Army for Operations Research, that the military OR community could go the way of the dinosaurs if we were not careful. This warning seemed to hearken to the early days of OR with multi-disciplined teams of experts solving complex problems. And, it was during this time frame that the Defense Modeling and Simulation Office (DMSO) formed and not long afterwards that the Army's Model and Simulation management began critical actions that have shifted the OR paradigm back toward the multi-disciplined concept.

The DMSO gathered experts from around DoD to attack how to think about and how to develop the next generation of problem solving Models and Simulations. The Army Model and Simulation Office (AMSO) established a group of Standards Categories and Standards Category Coordinators composed of a mix of experts from all functional areas of combat Modeling and Simulation research and development to attack in order to set the stage for the next generation of tools and techniques to use in OR and in building Models and Simulations.

The impact of DMSO, AMSO and similar activities can be seen if you think of the Military OR community as a machine with input, just like the Models and Simulations it produces. This community — the black box of OR — is composed of many groups of humans, who together describe different transformations of transformations with their behavior over the nature of OR. And, when you examine this OR black box over the past 30 years or even the past 50 years, we can see that the insides of the black box of professional military and civilian operations researcher is autopoietic. That is, the insides of the black box are self-creating the boundaries

or walls of that black box through their dynamics of operation. A key part of this autopoietic change is the inclusion of the groups such as DMSO and AMSO. It appears that the appropriate requisite variety has shifted.

The Paradigm Shift of M&S

Today's OR problems are just as complex as they were in World War II. Often the problem statement is ill-structured, composed of the perceived situation, the desired situation, and the actual situation, as well as involving international elements, having conflicting value systems, multiple policy actors, and exhibiting self-reference. The combination of the above is the difficulty, the complexity, and how the OR black box poses the complex analysis question to be answered is today's challenge. A companion of this challenge is to understand the requisite variety needed within our combat models and simulations. The answer to this next challenge of requisite variety, is in the very large combat simulations like JWARS.

JWARS not only is a new combat model or simulation, but a metaphor for a new paradigm shift in thinking about and building such systems. In the last 30 years of computer combat Models and Simulations the OR paradigm focused on attrition-based Models and Simulations, and provided a rich literature to examine the limits of algorithmic truth approaching battle truth. JWARS has shown an evolution of that paradigm with its information-based system that is more like the elements of real life. That is one key element of the paradigm shift in M&S.

The foundation of the complex legacy Models and Simulations could also be described as non-trivial machines. That is, the history of the processes inside the model or simulation was not observed or transparent to an outside observer or the results. One built these machines from deterministic parts, sequentially linking processes, which are now being replaced in new language and in implementation. This other key element of the M&S paradigm shift is the OR communities' acceptance of object oriented programming (another language legacy from the early efforts in AI programming).

Along with improving computer technology, the increased variety of the OR community, and object oriented thinking and practices, we have a paradigm shift in M&S. But, not without a price.

The workings of a non-trivial machine are difficult if not impossible to explain and understand. The human and human organizations are non-trivial machines. Now, with systems such as JWARS we are creating more real life expressions of human decision-making, of command and control. So, a third key to the new paradigm of M&S is for JWARS to be able to show causality for its decision making processes. This means creating a complex machine that does not exhibit the limitations of non-trivial machines. JWARS must be transparent in its complexity, yet not have complexity drive events into chaotic conditions. This is a process of managing complexity, similar to managing a complex chemical reaction. JWARS then, is evolving the requisite variety to contain a potentially highly unstable reaction. It is putting constraints on chaos.

The shift in OR and M&S paradigm together have launched a new era of capability driven concepts and research programs that have buffeted the threat of OR going the way of the dinosaurs. Thus, we have the first critical paradigm shift that is necessary in the next evolutionary step leading the M&S community into the next century.

The Paradigm Shift in Analysis

The OR community has the responsibility of advising decision makers on the degree of belief to ascribe to the results of its M&S tools. We ask such questions as: How do we measure the results of a combat model or simulation? What is the difference between the empirical results of testing military systems and the synthetic testing inside a model or simulation?

During the Cold War era, analysis had a decided bias toward weapon systems acquisition. A debate ran through the OR community about whether or not to use a simple model or a more complex model. Accuracy in data quality was a routine plague. Eighth grade arithmetic leveled the language barrier between analyst and decision maker. The scientific method was not used, relying on more art than science. Analysis was not geared toward problem solving, but more like a detective's investigation of facts. Analysis was not looking for tradeoffs from branch to cross-branch to campaign levels. Models as large as JWARS often saw the model builder more interested in the model than in the analysis.

Perhaps during that time the often heated discussions and debates about what OR techniques were being used and what M&S results could be believed, probably contributed the most value to the improving analysis products. Thanks in part to efforts from DMSO and AMSO, and to the debates and discussions from MORS contributors, we have created a climate of a more consistent analytical product, with verification and validation of the M&S and data.

But has there been a paradigm shift in analysis of complex warfare as there has been in the OR cross leveling of talent and M&S? The answer seems to be yes, but, again it is tied to the emerging concepts hosted in model development efforts like JWARS. That is, the measures of effectiveness that are traced from the basic analytical question to the applications of programming techniques must also be transparent as the complexity of JWARS increases. This visibility will help foster a new way of looking at what analytical questions to ask of such complex combat models. But, to better understand this, we should examine the basic complexity of JWARS.

JWARS

The Joint Warfare System (JWARS) is an analytic model of combat at the theater level. Currently, a prototype has been built and tested with the production version under way. JWARS will be a closed-form simulation. A key difference between JWARS and the similar legacy models and simulations of the past 30 years is that it is information-centric. Legacy models and simulations have been traditionally attrition-centric. This means that intelligence fusion is central to the operation of all elements within the simulation, which gives the user community an analytical tool to analyze the complex impacts of C^4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance) to a complex fit of joint military service weapons and combat support subsystems.

The model is a closer approximation to real-world joint operations than any previous similar legacy model or simulation. Some of the joint operational or mission

(See **JWARS,** *p. 20)*

Verification and Validation Issues for Training Simulators

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Issues concerning the verification and validation of simulations are one of the classic problems facing today's operations research analyst. There are several problems with existing verification and validation techniques, and there is a need for a structured approach to verification and validation. The purpose of this article is to review the status of current verification and validation efforts as they relate to training simulators, and to propose a methodology for effective and efficient verification and validation efforts. The methodology, verification and validation through interim experimentation, will be presented in a broad sense. This article will be followed by another article that presents a specific structured approach to interim experimentation.

One major problem with current verification and validation is a lack of organization of effort, or a guiding theory. This results in experiments that are poorly designed that cannot provide the desired data, that answer the wrong questions, or that duplicate efforts. **Pace** (1995) suggests that many present verification and validation efforts become mainly judgment based. This condition results in many efforts for verification and validation containing unwanted variability. Consequently, simulation credibility is much less than desired. A structured approach is needed to ensure experiments are designed and organized correctly to establish quantifiable criteria and data for verification and validation. The need for this guiding theory is perhaps even more crucial for the training simulator due to their high cost and lengthy development cycle.

Another problem associated with traditional verification and validation efforts is that they are manpower and resource intensive. The result of this condition is that the verification and validation tests are often limited in scope because of cost. It is not unusual in some systems to find that a thorough verification and validation effort could exceed the cost of the product development (Gledhill, 1994). The cost of experimentation and of error correction is magnified the later in the product life cycle the experimentation is conducted. A structure guiding experimentation for verification and validation that starts early in the product life cycle and is used at discrete intervals will help alleviate the manpower requirements and the cost of experimentation and/or error correction. Several smaller scale tests conducted through the life cycle will also help develop a better product than one large test at the end of development.

Today's training simulators are built upon very large training matrices that are quite complex, and this complexity creates problems for verification and validation efforts. As technology continues to move forward, the enumeration of all possible training scenarios may no longer be feasible because of length of time required and cost. If an experimenter tries to enumerate all of the possibilities, a hit or miss procedure will result, and the tester will not obtain a good representation of all training conditions that exist in the simulator's training matrix. Verification and validation tasks, like algorithm analyses that were once considered optional, are now mandatory to verify that applications interface correctly with hardware. The result of more complex systems is that verification and validation should be used earlier and throughout the entire life cycle (Dunham, 1989).

The lack of a standard guiding theory oriented specifically towards training simulators is another basic problem associated with verification and validation. There is a great deal of individual information available for verification and validation of software, for verification and validation of simulation models, and for system testing for specific production items. Training simulators involve a combination of each of these three fields, so when testing, theory from each field is applicable. A set of rules or a structure for combining the theory would be very helpful, because when each are integrated separately, problems can easily be created, or critical items may be overlooked.

One way to overcome these verification and validation problems mentioned earlier is to conduct verification and validation at discrete points in the simulator development cycle. Before the opportunities available for interim tests can be presented, verification, validation, and interim experiments must be defined. According to *Department of the Army Pamphlet 5-11* (1993) the purpose of verification of the system is to determine that the system functions as it was originally conceived, specified and designed, and that it meets the needs of the user as specified in the requirements documents. *Department of the Army Pamphlet 5-11* (1993) states the purpose of validation of the simulator is to determine the extent to which the system accurately represents the intended real world phenomenon from the perspective of the customer of the system. The interim tests should be used as a vehicle for verification and validation of the system under development. One of the greatest benefits to this interim testing organization is that the verification and validation will have the input and approval of both the user and the producer. Verification and validation is one of the most resource intensive phases in the development of a training simulation system. It is also the most crucial to the success of a program. Verification and validation efforts are a part of the simulator's product development cycle that occur between the development of a prototype system and the system's production. Verification and validation efforts can be extended to a system after it is fielded. However, the approach used in this discussion will strive for identification and resolution of issues prior to production. The verification and validation will be conducted through the use of interim experimentation.

An interim experiment is an exercise involving both the producer and the user of a training simulator. It is conducted throughout the product development cycle, with a purpose of ensuring that the system under development is meeting some agreed upon specifications or require-

ments. The exercises, or testing, should begin early in the product life cycle and should be conducted at stages throughout the product development cycle. The producer is the organization contractually responsible for the production of the device against detailed requirements or specifications. The user is the agency that needs the system under development to fill a specific training requirement. The user is the originator of the statement of requirements or specifications documents. There may be several organizations and players structured within the user agency. There may be a separate group detailed with the acquisition of the training system, such as the Simulation, Training and Instrumentation Command (STRICOM). There will be a specific training audience within the user group, like the tactical units that will eventually train on the simulators. There will also be several different types of subject matter experts within the user organization. These experts will be called upon at different intervals to ensure the training simulator is behaving like the modeled system. Some of these experts may be experts in training devices or simulators. An example of this type of expert are the instructor/operators (I/O) for the simulators at the US Army Armor School. Some may be field matter experts in the area for which the training simulator is being developed, like the soldiers who have spent the majority of their careers on the actual equipment being simulated. All of these participants will serve various important roles in the interim experiment process. The interim experiment can be conducted at different levels for different purposes. It can be a demonstration of the progress of the current development of a system, or it can be a concurrent engineering effort attempting to curtail changes late in the product life cycle. It can be a one time exercise for a prototype system that is used as a production milestone or it can be a sequential test following the test, fix, test methodology. The interim experiment can be many things to many products. There is no exact solution for organization of every system.

Before a quantifiable structured approach to verification and validation of simulators can be developed, a process for organization is required. Component level is the first level analyzed. The producer team should develop a list of all major components of the training simulator. From this list, both teams will jointly determine which components are critical and warrant the participation of both the user and producer in verification and validation through the means of an interim experiment..

Each team should develop a list of personnel required for participation in the component level of testing. Each team leader is responsible for his own group. Lists should be agreed upon by both teams, so each team is happy with representation provided by the other group. From the user team, potential personnel include those who can readily check software code, methodology of the code, structural and static validation, and other details of the component nature. From the producer team, members who can readily explain and correct code errors, structural errors, or defend logic of the methodology of each component would be ideal candidates. This list will form the interim experimental exercise team for the component level. The producer and user teams should also agree on the role and participation of the independent review team at the component level.

Given the list of critical components to check and the requirements and availability of critical personnel on each team, the testing team chief should determine how many exercises are required to capture all of the required items. The team chief should present this data to the user and producer leadership for approval. This number is the number of experiments conducted at the first level.

The following example of a tank simulator should clarify component level issues. Components involved are the data base, used for storing information files; the gunner's power control handles, used for firing the tank; the tank commander's independent thermal viewer, used for acquiring and engaging targets; and the instructor/ trainer's display panel, used for monitoring the training session. There will always be a large number of individual components, but all are not critical. Testing the gunner's control handles is probably not a critical item for all members of the testing team, especially if the part is relatively common. If the commander's independent thermal viewer is a new addition to the simulator, and has never been seen before by the user on a simulator, then it could be considered critical and worth detailed testing. The next level to consider is the integration level.

Integration level analysis is done after the component level. The producer team should identify each phase of integration of components from individual components through complete integration. From this list both the user and producer team leaders should decide which phases are significant enough to warrant detailed experimentation. The testing team chief, again, resolves conflicts and offers advice.

The user team leader should identify personnel who are experts needed to compare integration and system response given specified inputs with responses of real systems. The list should include personnel familiar enough with the simulator to be able to explain accepted trade-offs. From the producer side, the team leader should include experts able to readily correct interface errors, and debug systems given indicator errors.

The testing team chief needs to compare the number of critical phases of integration to the number and quantity of required personnel from all sides in order to determine the number of required exercises at the integration level.

Examples of integration on a flight simulator are combining the flight control system and the gunnery/armament system in an Apache flight simulator. The specific code issues of the computer interface may be of less interest to the user than the end result of what happens when a trigger is pulled in the gunner's station.

System level requirements are checked after integration level. From the available training menu and the detailed system requirements and specifications, each team leader should determine which training components require detailed testing that involves both the user and producer. The independent review team should be included in this decision.

Each team leader is responsible for deciding which experts and participants will be needed at each level of the training menu to effectively compare the simulator with the real system, identify errors at the source and implement corrections, or discuss trade-offs accepted by all participants. The chief of testing again plays a large role in resolving problems. The testing chief will decide how many experiments should be conducted based on the list of critical training menu checks and required personnel.

(See **TRAINING SIMULATORS,** *p. 24)*

PHALANX PHELLOWS TRIBUTE

***John Key Walker**, Jr., 78, of Jensen Beach, Florida and Silver Spring, Maryland, died on 29 January 1998, in Stuart, Florida of complications following lung surgery.*

Jack graduated from Bedford (Virginia) High School; received a BS degree in 1941 from Virginia Polytechnic Institute and an MS in Management Science from George Washington University in 1971.

He entered the US Army in 1941 with an ROTC commission as 2nd Lieutenant. His commands included the 486th Anti-Aircraft Artillery Battalion of the 3rd Armored Division (World War II) and 3rd Brigade, 2nd Infantry Division (Ft. Benning, GA). Tours of duty included Headquarters, VII Corps (Germany), Command and General Staff College (Ft. Leavenworth, Kansas), the Army War College, (Carlisle Barracks, Pennsylvania), Allied Forces North (Oslo, Norway), Supreme Headquarters Allied Powers Europe (Paris, France), Army General Staff, Office of the Secretary of Defense (Pentagon) and

ARVN 5th Infantry Division (Viet Nam).

Decorations include the Silver Star with Oak Leaf Cluster, Distinguished Flying Cross, Bronze Star Medal for Valor and Legion of Merit with Oak Leaf Cluster.

In 1969 he retired as Colonel, then served as a military research analyst with The RAND Corporation, Washington, DC, from 1969-95.

Jack is survived by his wife, Toni, three daughters, three step-children, six grandchildren, four step-grandchildren, three nieces and one nephew.

A memorial service was held in Jensen Beach on 31 January 1998. Internment will be at Arlington National Cemetery at a later date. The family requests that contributions in Jack's name be sent to National D-Day Foundation, P.O. Box 77, Bedford, VA 24523.

Jack was the PHALANX Editor Emeritus, was elected one of the first Fellows of MORS in 1989, was a Past President of MORS and served the MORS community since 1969. He will be greatly missed by us all.

The following are tributes to Jack from some of his fellow MORS PHELLOWS.

— Natalie Addison

A Tribute to Jack from Wayne Hughes

Wayne Hughes, FS

The Board created the MORS Fellows, but **Jack Walker**, FS created the *PHALANX* Phellows. His column, so full of wit, says worlds about Jack's pixie imagination and devotion to service. If he could write his own memoriam doubtless he would wish us to know that even Phine Phellows are Phated but Phortunate to move to new and Phacinating Phases.

Jack Walker, FS is the very image of selfless service — three times over. In a full Army career of 27 years he rose from 2nd Lieutenant to Colonel, was in action in three wars, and seems to have been everywhere and done everything (an Army officer with a Distinguished Flying Cross?!). Then he started over again. At RAND he charted another career of more than 20 years, this time in operations analysis, which was equally notable for getting his job done with quiet competence.

Paralleling his RAND career was a third one with the Military Operations Research Society — maybe not full time, it's true, but performed without a whimper or a dime of compensation — and it lasted almost another 30 years. You'll find his column in the latest *PHALANX*, December 1997. So there you are: by my count, 80 career years, in series and in parallel, and as far as I know all 80 of them devoted to positive thinking, morale building, and unostentatious, responsible achievement

I came upon MORS at almost the same time as Jack. It was around 1970. He led me by only a couple of years, but in the eyes of young Commander Hughes, Jack was already one of the venerables. Nothing I saw him do ever changed my mind. One example. When I was MORS President I had (as I now recall) only one burning problem. Jack had been editor of *PHALANX* for what was already a very long time. Furthermore he had already served MORS in every other imaginable way, and he had for several years been dropping hints, subtle or blunt, that we needed a new editor. At Symposia and Board Meetings I winced every time Jack's camera flashed or he presented one of those albums of photos that were half esteem and half hatchet-job. My term ended with no replacement for him. I had done a lot of stroking so that Jack wouldn't quit and felt quite proud of my achievement. Such foolishness! I know now that Jack never walked away from anything in his life. He wouldn't have quit if I'd spit on him.

And the ranks of the Old Guard with memories of how it really was in World War II continues to shrink. Jack Walker did his share and a lot more to bring on three new generations, in the Army, in RAND, and in MORS. He is one Phenomenal Phellow. ✪

How I Remember Jack Walker

Steve Murtaugh, FS

How would such a good friend as **Jack Walker**, FS want us to remember him? This is the thought that comes to mind. As I prepare to write this portion of a tribute to Jack, for sure, each of us companion Fellows will have different approaches to what we write for this occasion, for Jack Walker was many things to each of us. But, to one and all, Jack was first a true friend (and that is a rare possession in today's world). This is exactly what Jack was, and is a prime reason why so many of us valued our association with him.

Jack went beyond mere friendship — he worked at it actively. For example, back in the early 60's, when I was a newly elected MORS Director, Jack and Clay Thomas, FS took me in tow and taught me how to contribute on the Board for my MORS career, always in true, caring friendship.

We all knew Jack as editor of the *PHALANX* — a job he did admirably for many years — but he did so much more for the *PHALANX*. He led the effort to expand *PHALANX* from a newsletter to a professional publication, expanding its size, attracting worthwhile authors, and instilling many innovative features. Jack initiated the series of *PHALANX* articles in which a different Fellow is written up in each issue for all the membership to read. This has been a richly successful feature in *PHALANX*; Jack's approach to writing these highly readable articles will be missed. We are all proud of the excellence Jack brought to *PHALANX* — the showcase of our Society's activities and personages.

Before *PHALANX*, Jack was helping to bond our Society in other ways. He chaired the 33rd Symposium and was elected President shortly thereafter. When Vance Wanner, Executive Secretary of MORS, died unexpectedly some years ago, Jack moved into the MORS Office, and with the early staff, kept the Society functioning until a new Executive Secretary could be found. Jack made the time to do this even though he was working full time at the RAND Corporation. When Ed Napier, FS agreed to be the new Executive Secretary, Jack stayed on to work with Ed and make the transition smooth. When we were developing the Society's first Code of Ethics, Jack came forward with all kinds of ethics materials from MORS and ORSA, developed when Jack chaired an ethics working group in early MORS days.

When five of us were selected as the first MORS Fellows, we wrestled with how the Fellows could continue to contribute as a group in some meaningful way to the Society. Once again, Jack was there with an abundance of good ideas to submit to the Board, and when we were charged by the Council with identifying those early MORS workers who would be Fellows candidates, Jack was there with suggestions and supporting guidelines.

These are but a few of the ways in which I shall remember Jack Walker. I have one more memory to share with you — and that is of Jack and his lovely wife Toni and their presence at each Symposium over many years. They always invited me to join them at the Symposia banquets. I especially recall the director's dinner at Annapolis in 1990 when Jack was toasted the evening before receiving the prestigious Wanner Award — even then Toni and Jack invited me to sit with them at dinner, always willing to share their good times.

I know I am a better person and, I hope, a better MORS contributor, because Jack and I not only crossed paths, but because Jack chose to walk with me at significant times in my MORS career, always there to help and to encourage. The records show that Jack Walker was one the of the first MORS Fellows, a Wanner Award recipient, and *PHALANX* editor emeritus, but in my heart, Jack will always be remembered as a true friend, and in the hearts of many others, I'm sure, a thoughtful counselor, and an ever faithful supporter. ✪

Tribute to Jack

Clay Thomas, FS

I can think of no one whose loss will be mourned by more of us "MORSians," than **Jack Walker**, FS. MORS, of course, is only one of the institutions that Jack enriched with his friendly help, dedicated industry, talented insights, and unparalleled sense of humor. But I knew him best as a MORSian who outstandingly epitomized so many facets of MORS, and whom so many of us remember as a warm, highly valued, and vital friend.

Slightly over a quarter of a century ago I was to chair the 30th MORS Symposium. Feeling a bit overwhelmed, I sought outstanding MORSians to fill the critical positions, and the first one I turned to was Jack Walker. Not only did he agree to be General Sessions coordinator, the key position of that time, but he accepted in that marvelously gracious way as if I were doing him a favor! And his top-notch performance was what we all came to expect as a matter of course, whatever his role.

In that period Jack came to be known in MORS for his innovative work on Ethics and Professional Practice. It was a subject of interest in other professional societies as well, but it was Jack who sensed the particular importance of the subject for a society with military sponsorship that sought to enhance the quality of operations research studies in an area critical to national defense policy. Jack's pioneering work paved the way for MORS' continuous and successful involvement in this area, and its reputation for high ethical standards.

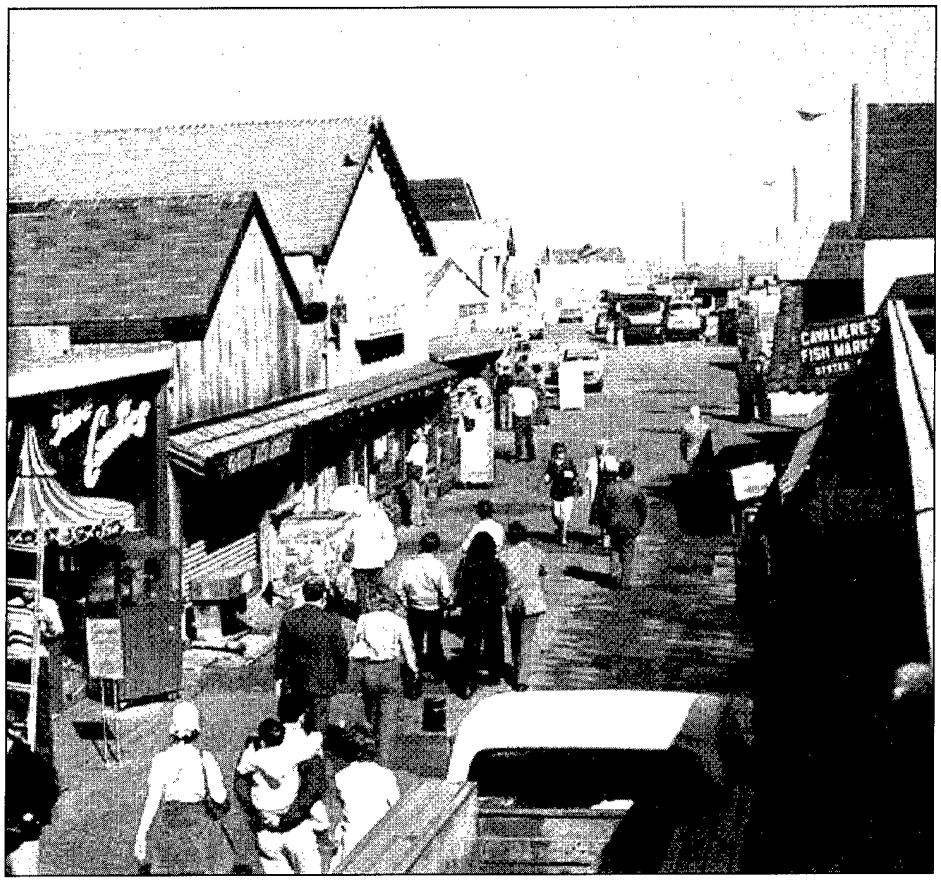
It was as *PHALANX* Editor, however, that Jack came to be so widely known, not only throughout MORS, but in other large OR professional societies as well. The original decision of the MORS Board of Directors in 1973 to accept the invitation to become a co-sponsor of the *PHALANX* Newsletter (from ORSA MAS) was far from popular. One Director resigned to protest what he thought was an unfortunate mistake! Of all those whose hard work transformed *PHALANX* from a small Newsletter to the large and successful Bulletin of today, Jack stands out for his dozen years as Editor (1979-1991). His introduction of new departments, active search for topical OR stories, irrepressible sense of humor, and, of course, his careful editing, were what set the *PHALANX* tone and made every issue rewarding.

I can picture Jack now, looking over our shoulders, commenting that this issue needs a little more work. ✪

Still *Need* a Reason to Go to Monterey?

RADM **Pierce Johnson,** Program Chair
Ted Smyth, Plenary/Special Sessions Coordinator
CDR **Ron Brown,** Site Coordinator

If you haven't made plans to attend the 66th MORSS, it is time to begin! The 66th Military Operations Research Society Symposium will be held at the Naval Postgraduate School (NPS) in Monterey, California, on 23-25 June 1998, with a theme of *Preparing for Military Operations Research in the 21*st *Century.* Early registration ends in just a few weeks (on April 19th). If you haven't decided on attending yet, here are a couple of reasons why you might want to consider coming: a quality keynote speaker; applicable, forward-thinking special sessions from our senior analysts and our senior leadership; and the overall magnificence of the Monterey Peninsula.



Plenary Session

The 66th MORSS is honored to have as its Keynote Speaker, Dr. **William J. Perry,** the former Secretary of Defense. Dr. Perry is currently a Senior Fellow at Stanford University where he holds the Michael and Barbara Barberian Professorship. Dr. Perry's Keynote Address will be delivered during the Plenary Session scheduled for 0830-1000, Tuesday, 23 June 1998.

Special Sessions

During the 66th MORSS, Special Sessions will be conducted daily from 1530-1700. A wide variety of activities are scheduled for each of the Special Sessions. The Special Session scheduled for Tuesday, 23 June will focus on the subject of "Leadership in an Information Dominant Battle." The purpose of this Special Session is to challenge the audience to reconsider the relative importance of technology and leadership in an information dominant military. It is anticipated that participants will address the relationship that exists between technology and leadership and the synergy that may be derived by effectively nurturing and developing the two. Other activities scheduled during the Tuesday Special session include reports from several Mini Symposia to include the September 1997 Mini Symposium on "Complexity and Warfare Analyses" and the planned April 1998 Mini Symposium on "Analysis Requirements for the Next QDR." Prize Paper Presentations are also scheduled for the Tuesday Special Session.

The Wednesday, 24 June Special Session will focus on the issue of "Validation Methodologies." It is anticipated that several case studies will be presented and discussed by a select number of panelists. Panelists will briefly describe the model in question, the techniques used in the validation effort, and emphasize the lessons learned from the validation effort. Other activities currently planned for the Wednesday Special Session include a report from the December 1997 SIMTECH 2007 Workshop and the popular Junior/Senior Analyst session.

The Thursday, 25 June Special Session will focus on a Navy 3-Star panel discussion on the subject of "Preparing Today's Operations Research Analysts for the Next Century." Invited panelists include Vice Admirals **Lautenbacher, Redd, Cebrowski, Oliver,** and **Tracey.** All of these invited officers have either an operations research background and/or considerable experience and knowledge of the contributions provided by the operations analysis community in support of both operational and program requirements. Other activities scheduled for this third and final Special Session include reports from the Spring 1998 Education Colloquium and the January 1998 "DoD Infrastructure" Mini-Symposia.

History of the Naval Postgraduate School

The Naval Postgraduate School began to evolve when the idea for a graduate education program for naval officers first emerged in the late 19th century. Initially, the concept found few advocates. With Marconi's invention of the "wireless" in 1901, the Wright brothers' flight in 1903, and the global trek of the steam-powered White Fleet from 1907 to 1909, the concept of advanced education for US Naval Officers gained support.

On 9 June 1909, less than four months after the completion of the record-setting world cruise of the Great White Fleet, Secretary of the Navy **George von L. Meyer** signed General Order No. 27, establishing a school of marine engineering at Annapolis. This small program, consisting of 10 officer students and two Navy instructors, would later become today's Naval Postgraduate School. The Navy secretary's order placed the fledgling school under the direction of the Naval Academy superintendent, who was charged with "securing ample use of the educational plant of the Naval Academy for students and instructors of the school without interfering with the instruction of midshipmen." This translated into two attic rooms being set aside for classroom and laboratory space for the school.

Within three years, Meyer agreed to a proposal to change the school. On 31 October 1912, he signed Navy General Order No. 233 which changed the school's name to the Postgraduate Department of the Naval Academy and added courses of study in ordnance and gunnery, electrical engineering, radiotelegraphy, naval construction, and civil engineering to the original program in marine engineering. Enrollment increased to 25 officers who finished their academic programs at civilian institutions such as Yale, Harvard, the Massachusetts Institute of Technology and The Johns Hopkins and Columbia Universities after attending the school.

During World War II, Fleet Admiral Ernest King, Chief of Naval Operations and Commander-in-Chief of both the Atlantic and Pacific fleets, established the Pye commission to review the role of graduate education in the Navy. This group's recommendations were regarded highly within the Navy and Congress. In 1945, Congress passed legislation to make the school a fully accredited, degree-granting graduate institution. Two years later, Congress adopted legislation authorizing the purchase of an independent campus for the school.

After examining 25 sites nationwide, a post-war review team recommended the old Del Monte Hotel as the Postgraduate School's new home. The Navy had first come to Monterey in early 1943 when it leased the Del Monte Hotel for a preflight training school, which was subsequently used for other training programs. Negotiations with the Del Monte Properties Company led to the purchase of the hotel and 627 acres of surrounding land for $2.13 million.

In December 1951, in a move virtually unparalleled in the history of academe, the Postgraduate School moved lock, stock and wind tunnel across the nation, establishing its current campus in Monterey. The coast-to-coast move involved 500 students, about 100 faculty and staff and thousands of pounds of books and research equipment and pumped new vitality into the Navy's efforts to advance naval science and technology.

Today's Postgraduate School is an academic institution that continues to emphasize study and research programs relevant to the Navy's interests, as well as the interests of other arms of the Department of Defense. Its 40 programs of study, specifically designed to accommodate the unique requirements of the military, provide advanced degrees in National Security Affairs, Aeronautical Engineering, Applied Mathematics, Applied Physics, Applied Science, Astronautical Engineering, Computer Science, Defense Analysis, Electrical Engineering, Engineering Acoustics, Engineering Science, Information Technology Management, International Resource Planning and Management, Management, Materials Science and Engineering, Mechanical Engineering, Meteorology, Meteorology and Physical Oceanography, Modeling, Virtual Environments and Simulation, Operations Research, Physical Oceanography, Physics, Systems Engineering, and Systems Technology. The student population has grown to 1,800 and includes officers from all five US uniformed services, the services of more than 25 allied nations, and a small number of civilian employees of the US government. The campus covers 627 acres of land and houses state-of-the-art laboratories, numerous academic buildings, a great library, government housing and impressive recreational facilities. Selection of officers for fully funded graduate education is based upon outstanding professional performance as an officer, promotion potential and a strong academic background. The faculty, composed primarily of civilians, is drawn from a broad diversity of educational institutions and represents a prestigious collection of scholars. Faculty/student interaction is high, with every class taught directly by a faculty member — over 99% have a Ph.D.

Monterey Peninsula

The Postgraduate School's setting on the magnificent Monterey Peninsula is one of the most diverse and beautiful areas in Northern California. Often called the greatest meeting of land, sea and sky, this beautiful seaside community combines all the charm of small town America with an endless variety of recreational and cultural activities. Monterey's rich history, the saga of California's Mission Trail, historic Fisherman's Wharf and Cannery Row, 17 world-class golf courses, the world's best aquarium, a unique variety of shops and galleries and a spectacular assortment of parks and natural areas combine to provide a truly unrivaled vacation or business destination.

Monterey itself is but one of several attractions of the Monterey Bay area. Visitors enjoy strolling the streets of Steinbeck's Cannery Row, absorbing the historical and cultural past of California's first state capital. Monterey also features Fisherman's Wharf and the Monterey Bay Aquarium in addition to its array of fine restaurants, boutiques, galleries, inns and other recreational opportunities. It is host to a wide variety of festivals and world class events including The Monterey Jazz Festival, The Monterey Blues Festival

(See **SYMPOSIUM,** *p. 20)*

SYMPOSIUM

(continued from p. 19)

(which is scheduled the weekend after the symposium), Cherries Jubilee, The Great Monterey Squid Festival and Monterey Wine Festival, as well as major automobile and motorcycle races at nearby Laguna Seca Raceway.

Nearby, Carmel-by-the-Sea had already achieved its international reputation as an artists' colony by the 1920's. Among its biggest attractions today are Point Lobos, Carmel and Lagoon Beaches, Ocean Avenue, The Tor House, Carmel Mission, and a variety of art and photography galleries in its downtown shopping district. You won't find many sidewalks, streetlights, neon signs or mailing addresses, but you will find specialty shops, boutiques, art and photography galleries and great restaurants. Pacific Grove, another local attraction, is famous for its thriving population of Monarch butterflies. A walk through its residential neighborhoods reveals many well-preserved, turn of the century, Victorian homes. History buffs can visit the Point Piños Lighthouse, the oldest operating facility of its kind on the California coast. The Monterey Bay recreational trail passes by Lover's Point, offering many opportunities to view sea otters, sea lions and occasionally passing whales. Yet another local attraction is the gated community of Pebble Beach. Popular destinations include the 17-Mile Drive, with its breathtaking views of the ocean, fabulous houses, Stillwater Cove, the Lone Cypress, and an array of world-class golf courses. Nearby, Carmel Valley is home to many wineries, farms, ranches and the beautiful Garland Ranch Regional Park. Finally, don't miss Big Sur with its Esalen Institute, Henry Miller Memorial Library, Point Sur Lighthouse, camping, hiking, beautiful redwood groves and excellent whale watching.

For those of you who are still undecided about attending the 66th MORSS, we hope we have provided you a couple of additional good reasons to attend. We will provide more information in the June PHALANX to help reinforce your decision to request a registration packet from the MORS Office. Plans are to include details for the tutorials, poster sessions, the Junior/Senior Analyst session, the Education Session, and the Prize Paper Session, as well as the specifics of the Spouse/Guest Program.

If you have any questions about the Symposium, please contact the MORS office at (703) 751-7290 or CDR **Kirk Michealson** at (703) 697-0064. Make your arrangements now to attend and participate in the 66th MORSS at NPS from 23-25 June 1998! ✪

COMMENTS

(continued from p. 7)

interdisciplinary problems successfully. As the wise man said, great things can be accomplished when you don't care who gets the credit. Whether better thinking and actions are achieved under the rubric of OA, IT, systems engineering, management science, or industrial engineering, the important thing is to help people think and act with perspicacity.

"Sg-nus"

Notes

1. By the dictionary, "discipline" is any branch of knowledge or teaching, but academics are inclined to apply a more stringent standard. A profession is an occupation requiring training in the liberal arts or sciences and advanced study in a specialized field.

References

[1] Hughes Jr., Wayne P. Editor. Military Operations Research Society, Alexandria, Va., 1997. pp 3-4.

[2] Hughes Jr., Wayne P. Editor. Military Operations Research Society, Alexandria, Va., 1997. ✪

JWARS

(continued from p. 13)

areas modeled are:

- C4ISR
- Intra and inter-theater transportation
- Logistics
- Firepower
- Land, air and sea operations

However, it is the C4ISR that is the infrastructure of all simulated systems and activities. Central to C4ISR operations is how it contributes to the development of an accurate picture of battle truth. JWARS represents such C4ISR information flows in the synthetic perceptions of battle truth that are used in the command and control of all operational decisions. And, as in live combat, determining the difference between the real versus perceived truth of the battlefield is central to determining success on the battlefield. How a staff or pilot or tank commander perceives the enemy's position and their own position in a battlespace relies on a complex array of sensor to target data gathering processes, communications, history of similar events, training, etc., all of which are complex dynamics that builders of combat models and simulations have been trying to solve for decades with computers and centuries with board games and other non-automated means.

The complexity aspect of JWARS for this paper will focus on the intelligence fusion process, which is the process of obtaining, sorting, and comparing information from different, disparate sensors. A key product from this intelligence fusion process is developing courses of action (COA) for a variety of threat weapon systems and organizational structures. In JWARS what ever the sensors see on the battlefield is what is used to make command and control deductions. JWARS does not use ground truth for decisions needed, but perceived truth. The degree of matching the two truths is measured by the degree of success of gathering sufficient target intelligence.

Part II, which will address Complexity of Decisions and the Challenges Ahead, will appear in the June *PHALANX*.

Biography

*Dr. **Oliver Hedgepeth** is Chief Scientist for Models and Simulations within the Information Systems Division of GRCI, Vienna, VA. He is also an Adjunct Assistant Professor at Old Dominion University, teaching Technology Forecasting. Dr. Hedgepeth completed 30 years of civil service in 1997, developing, managing and researching M&S and data standards, with his final assignment in the AMSO.* ✪

4th Annual Air Force Operations Research Symposium

Lt. Col. **Jerry Diaz** and Dr. **Roy Rice**

The Fourth Annual Air Force Operations Research Symposium (AFORS) was held at the Air Force Institute of Technology (AFIT), Wright-Patterson AFB, OH, 22-23 October 1997. The symposium featured professional exchanges, briefings on military and civilian career management, updates on current AF policies on analysis, modeling and simulation, and MAJCOM "job fairs." Hosted by the AFIT OR Department, the symposium was sponsored by the AFMC Office of Aerospace Studies (OAS). Briefings from the conference can be found at www.plk.af.mil/oas.

This year's theme, "Air Force Analysis: Proud of the Past — Poised for the Future!" was highlighted by keynote speaker Mr. **Clayton Thomas**, Chief Scientist of the Air Force Studies and Analyses Agency. His presentation on "Fifty Years of Air Force Analysis" was of particular significance with 1997 being the 50th Anniversary of the Air Force.

At AFORS, Brig Gen **James "Sandy" Sandstrom**, Director of Command & Control, HQ USAF/XOC, recognized the Analysts of the Year. These awards honor the top AF military and civilian analysts for their outstanding contribution to unit mission, impact on an AF decision, and improvements in OR methodology. The four award categories are: 1) Company Grade Analysts of the Year; 2) Field Grade Officer Analysts of the Year; 3) GS-7 to GS-12 Civilian Analysts of the Year; and 4) GS-13 to GS-14 Civilian Analysts of the Year. This year's competition was exceptionally keen with 30 analysts nominated from around the world and across all mission areas. Mr. **Allen Murashige**, Chief Scientist to USAF/XOC, presented the awards at the Analyst of the Year Luncheon.

The Junior Civilian Analyst of the Year is Mr. **Jeff Beekman**, 422nd Test and Evaluation Squadron. Jeff developed a methodology for approaching, executing, and analyzing Tactics Development and Evaluations (TD&Es), which he briefed to the Combat Air Forces Tactics Review Board. His recommendations were accepted and used to develop the Air Combat Command test program for TD&Es involving F-16s, F-15Cs, F-15Es, F-117s, A-10s and HH-60s. Jeff also reviewed, improved and refined the MLU Test Plan of European F-16s. As a result, Jeff was handpicked by the F-16 SPO to represent the USAF as the lead analyst for the MLU Test, a one year tour in the Netherlands.

L-R: Mr. Frank Campanile, Capt. Jeffery Weir, Maj. Glenn Rousseau, Maj. Robert Nuanes, Mrs. Karen Somers, Mr. Allen Murashige

Mrs. **Karen L. Somers** is the Senior Civilian Analyst of the Year. Karen distinguished herself while working for HQ Air Combat Command (ACC) Plans & Programs Studies & Analysis Squadron, Langley AFB, VA. As the leader of the "Quick Look" Analysis Team, Karen provided ACC's senior leadership with timely analyses impacting near-term decisions on critical issues. During the past year, she led 13 quick response analyses which included Bomber Force Assessment, C-130J Stretch Analysis, HH-60 Rescue, B-52 Tanker Requirement, Barksdale Pharmacy Analysis, Combat Search and Rescue Requirements, and Concept of Operations for Advanced Systems in Operations Other Than War.

Karen's analysis played an important role in decisions influencing ACC and the Combat Air Forces. Her C-130J Stretch Analysis was used by SAF/AQ in preparing Congressional testimony defending the Air Force's decision not to procure the stretch version of the C-130J. In addition, the Bomber Force Assessment, which was briefed at the Spring 1997 CORONA Conference, proved critical to revalidating the need for the B-1 as the "backbone" of the bomber fleet.

The Company Grade Military Analyst of the Year is Capt. **Jeffery D. Weir**, US Strategic Command/J5. Jeff was a key player in a highly select group performing START III analysis last fall. He established critical parameters to the framework of this study that allowed the analysis of various treaty positions. His results were briefed to the Chairman of the Joint Chiefs of Staff, Secretary of Defense, and the President of the United States. The President ultimately used Jeff's analysis to set the bounds of negotiation with Russian President **Boris Yeltsin**. Jeff was also a central figure when the Secretary of Defense declined to fund an electromagnetic pulse nuclear detonation detection. Jeff combined OR techniques with control theory Kalman filtering to assess sensor impacts. This became the "definitive" answer on USSTRATCOM force management capabilities as well as the tool to measure future alternatives. This analysis initiated a USSTRATCOM J5/J6 in-depth review of battle management requirements and ulti-

(See **AIR FORCE,** *p. 22)*

AIR FORCE

(continued from p. 21)

mately supported Joint Vision 2010 strategy. Finally, Jeff developed a statistical methodology for annual test requirements for missile operational testing and reporting. His approach, which focuses the process on warfighter risk, provides realistic testing rates, and conserves critically scarce resources as well as money.

Because of their outstanding contributions, two Field Grade Analyst of the Year recipients where chosen: Maj **Robert A. Nuanes** from HQ Air Force Studies & Analysis, Washington DC, and Maj **Glenn G. Rousseau** from HQ Air Mobility Command Studies & Analysis Flight, Scott AFB, IL. Maj Nuanes distinguished himself by developing an innovative methodology that relates unit OPTEMPO/PERSTEMPO to unit stress. As Study Director for the CSAF directed Stressed Systems Study, the AF impact of his findings includes: programming 2 additional Rivet Joint aircraft, 7 Rivet Joint additional crews, reducing exercises by 5% in 1999 and 2000, eliminating QAFAs effective 1 January 1998, and establishing a post-deployment standdown policy. Both *Air Force Magazine* and the *AF News Service* published articles on the study and its positive effects. There have also been articles about the study in the *Washington Post, Washington Times, The Los Angeles Times,* and *The New York Times.* As documented in the Congressional Record, Congressman **Skelton** advocated AF action based on the study findings in a House floor speech.

Maj Rousseau distinguished himself as the 1997 Field Grade Analyst of the Year by leading an analysis of the AMC requirement to comply with the Global Air Traffic Management (GATM) system. Glenn's analysis showed that failure to fund GATM results in unacceptable delays delivering troops and equipment to theater warfighters. His results have been briefed to the AF Requirements Oversight Council, the Joint Requirements Oversight Council, at CORONA TOP to all 4-star senior leadership, to the Chief of Staff of the AF, and the Chairman of the Joint Chiefs. As a result of Glenn's analysis the Deputy Secretary of Defense included GATM as an important initiative in this year's DPG, 4.5 Million dollars was added to AMC FY98 budget, and the House National Security Committee recommended a 67.7 Million dollars "plus-up" for FY98. Major Rousseau also developed a testing strategy for new versions of large simulation models used in AMC. His use of univariate statistical measures, discriminant and cluster analysis techniques, and factor analysis to detect differences between two versions of the same model represents a huge improvement in the application of operations research for model development.

In addition to Analyst of the Year Awards, AFORS presented its first Lifetime Achievement Award to Mr. **Frank Campanile**, ASC/XRA, whose long history of outstanding technical accomplishments has spanned 36 years of Federal service. His distinguished contributions in aircraft performance, precision navigation, target acquisition, sortie generation, electronic warfare, weapons effectiveness and delivery, and conventional and non-conventional survivability and vulnerability, has supported the highest level decision makers in military aerospace system development and acquisition. His ability to perform thorough and highly credible analyses has saved the Air Force vital dollars and resulted in highly capable, affordable military systems.

Highlights of Mr. Campanile's career include the AGILE FALCON STUDY which investigated the military utility of four different conceptual aircraft configurations for a modified F-16, Chief Analyst for the Dual Role Fighter Evaluation, which supported an Air Force source selection to decide between two candidates, the F-15E and the F-16E, for a new dual role fighter aircraft, and a long history of support to the F-22 fighter aircraft program. He led the analytical activities and developed the methodology to evaluate 20 concepts and provided expertise for cost and operational effectiveness analyses and helped refine the aircraft design.

A list of other projects he has had a significant role in reads like a "Who's Who" of combat aircraft: AMRAAM Cost Reduction Program, AC-130U Gunship Accuracy Test and Verification, Military Utility of LANTIRN, Advanced Manned Supersonic Aircraft (B-1), the Close Air Support A-X (A-10), Tactical Air-to-Air Capability Study FX (F-15), and the Tactical Fighter Avionics Study (F-111 Mk-11 avionics). ✪

A Review of *Military Modeling for Decision Making, 3rd edition*

Edited by Wayne P. Hughes, Jr.
Alexandria: Military Operations Research Society,
1997, 375 pp. $40.00 (paper)

Intertwined in virtually all aspects of military decision-making — from what weapons governments should buy to how soldiers should use them — is modeling. This volume, now in a third and substantially revised edition, provides the most useful overview of the subject by some of the most notable figures in the field. The editor, a navy captain who has written authoritatively on a number of subjects (naval tactics in particular) sets the tone in a masterly overview that stresses, as do many of the essays that follow, the limitations of these artificial and simplified representations of the warrior's world. Driven too frequently by underlying assumptions about quantitative factors (firepower and numbers) rather than qualitative realities (morale, cohesion, coordination) military models can mislead those who put excessive faith in them — as the wildly pessimistic projections of American casualties in the Gulf War demonstrated. A work that, if read with care, would do much to reduce the simple faith placed by civilian and soldier alike in these ubiquitous attempts to distill reality into equations.

This review can be found in Foreign Affairs — Recent Books on International Relations, pg. 159.

OPTEC Team Wins Top ORSA Award

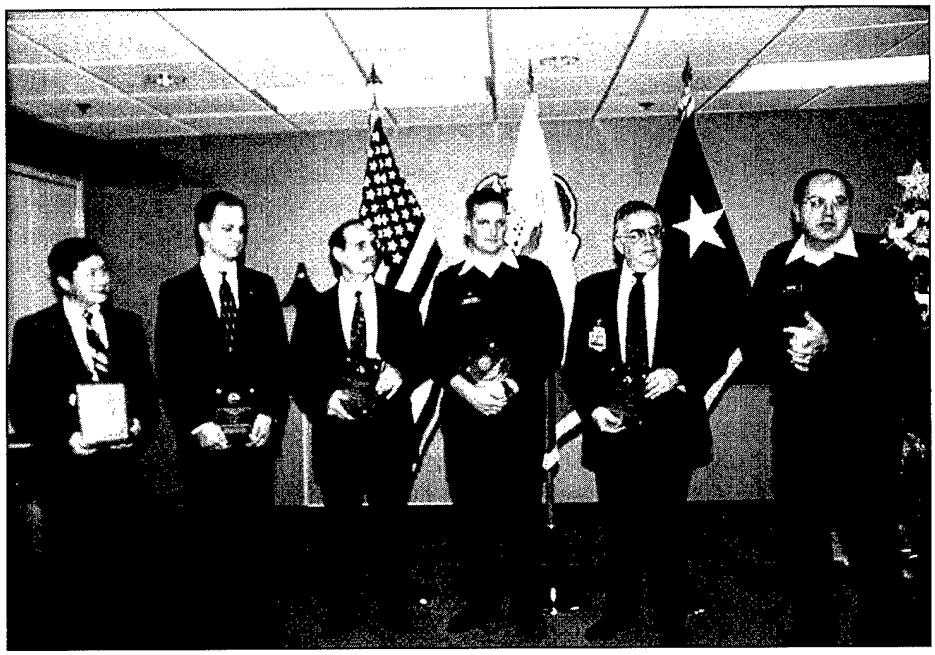
Cindy McGovern
OPTEC Public Affairs

The Operational Test and Evaluation Command's (OPTEC) Task Force XXI Advanced Warfighting Experimentation Team received the Dr. **Wilbur B. Payne** Memorial Award for Excellence in Analysis for best group analysis for 1997. The Payne Award is presented by the Deputy Under Secretary of the Army (Operations Research) (DUSA (OR)) and recognizes technical achievement in Army operations research and systems analysis.

One group award and one individual award are presented annually. The group award is intended to recognize a team that provides an exceptional product and is not intended to recognize an organizational entity for the totality of its work output. In the case of the OPTEC team, the product cited for the award is the "Task Force XXI Advanced Warfighting Experiment (AWE) Live Experiment Assessment Report." In a letter announcing the award, Mr. **Walter Hollis**, DUSA (OR) stated, "This report reflects timely analysis of experimental concepts and systems which are of utmost importance to the 21st century Army."

OPTEC was tasked by the Chief of Staff of the Army with providing an unbiased view of the AWEs to the Army's senior leadership. OPTEC had the lead in the Army for data collection, data management and live assessment of the Task Force XXI AWE. OPTEC's assessment mission was to provide independent assessment of the Applique and tactical Internet, 72 modernization initiatives, 32 joint venture issues and 10 force level capabilities. To accomplish this mission, OPTEC collected data — a total of 26 gigabytes — during four rotations at the National Training Center (NTC), including the culminating event, the Task Force XXI rotation in March 1997. The team also analyzed thousands of soldier comments and conducted interviews with almost every commander and soldier in the rank of captain and above who participated in the Task Force XXI AWE.

To analyze the overwhelming amount of data, the OPTEC team focused on identifying and validating trends rather than the cause and effect of specific events. The OPTEC team also used a three-tiered analysis strategy that focused first on military subject matter experts and observer/controller comments. The second tier focused on the analysis of available radio data, other electronic data and battle outcomes and served as verification for the personal observations. The final tier focused on modeling and simulation data which was provided to TRADOC's Analysis Center at White Sands Missile Range to support their constructive and virtual analysis efforts.



L-R: Koon Kityu, John Cox, Thomas Zeberlein, Lt. Col. William Carlton, Frank Pipicella, Col. Richard Sayre, Maj. Gen. Larry G. Lehowicz (OPTEC Cmdr)

In addition to a comprehensive final assessment report, the OPTEC team provided four interim assessment reports and nightly emerging insights briefings at NTC to senior leaders across the country via video teleconferencing. OPTEC's Task Force XXI reports have provided input for Army funding decisions and the Warfighter Rapid Acquisition Program (WRAP), development of system requirements and information architectures, and organizational changes for the Army's 21st century digitized division and corps.

The OPTEC report was truly a team effort with 14 members from three different OPTEC elements, the Operational Evaluation Command (OEC) located in Alexandria, Virginia, the Evaluation Analysis Center (EAC), located at Aberdeen Proving Ground, Maryland, and the Test and Experimentation Command (TEXCOM) located at Fort Hood, Texas.

The Payne Award was initiated in 1980 as the Department of the Army Systems Analysis Award. In 1987, the award was renamed in honor of Dr. Wilbur B. Payne, the first DUSA (OR). Payne is also remembered for his mentorship of the Army's best and brightest analysts.

The winner of the individual award is MAG Patrick J. DuBois, Ph.D., from the US Army Analysis Concepts Agency. Please see the June *PHALANX* for a full article on MAJ DuBois ✪

TRAINING SIMULATORS

(continued from p. 15)

An example of this level of testing is integration of tank, infantry fighting vehicles, and helicopters in a tactical training simulator. The type of experiment will most likely involve the higher end and more difficult scenarios in the simulator's training matrix. Testing that stresses the system is the focus of this level.

The final organizational level for testing is acceptance testing. The benefit of interim experimentation is reduced requirements at the final testing level. The testing at this level should focus on critical verification and validation issues that have either been carried over from a previous level with errors, or have special interest from the producer or user. The team leaders and testing team chief should jointly decide which issues need to be tested again. Because IEDM can be integrated into existing acquisition systems, the Milestone 3 production tests required in the US Army acquisition system is an example of an acceptance level test.

The total number of interim experiments required is the total of each of the four levels. This number, as well as the scope and required participants, should be outlined and agreed upon formally in a master test plan. This plan should be a fluid document because system and acceptance level testing requirements can be affected by previous interim experiment performance. The last check in the first step of the IEDM model is ensuring that all written system specifications and requirements have been captured in at least one of the designated levels.

In this article the current efforts of verification and validation, and problems associated with them, were discussed. A process for approaching verification and validation of simulators has been suggested. A need has been identified for a structured approach to verification and validation through interim experiments. The subsequent article in this series, *Interim Experiment Design Model – A Verification and Validation Process for Training Simulators,* will provide an approach.

Statement of Contribution

As technology increases and costs for training the new technology escalate, simulators will increase in importance and complexity. This will create a more urgent need for a structured approach to verification and validation of new simulators. The approach needs to minimize effort/cost and to provide a maximum of information. The first article identifies the state of current verification and validation efforts and focuses on the development of a structured approach for verification and validation of training simulators. The approach combines in a unique way principles gathered from current verification and validation theory, systems engineering principles, quality assurance theory and experimental design techniques. The interim experiment design model described in article two is a management tool that will improve the organization of interim experimentation and verification and validation efforts. This improved organization allows for detection of errors early in the product life cycle. The efficiency of subsequent experiments will be enhanced as a result. The early detection of errors coupled with the improved efficiency will provide verification and validation at reduced cost.

Abstract

This series of articles centers on the use of interim experimentation for verification and validation of training simulators. The first article identifies the state of current verification and validation efforts and focuses on the development of a structured approach for verification and validation of training simulators. The second article outlines a methodology using interim experimentation for verification and validation. The result is an Interim Experiment Design Model.

The issue of verification and validation is a primary concern for today's operations research analyst. Applying verification and validation to training simulators results in a combination of principles gathered from current verification and validation theory of simulation models, systems engineering principles, quality assurance theory, and experimental design techniques.

The interim experiment design model provides a management tool that will improve the organization of interim experimentation and verification and validation efforts. This improved organization allows for detection of errors early in the product life cycle. The efficiency of subsequent experiments will be enhanced as a result. The early detection of errors coupled with the improved efficiency will provide verification and validation at reduced cost.

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Biography

*CPT **Chris Hill** is currently serving as a mission analyst for the US Army Recruiting Command, at Fort Knox, Kentucky. CPT Hill began his career as an armor officer. He is a recent graduate of the operations research program at the University of Central Florida, in Orlando, Florida.*

*Dr. **Linda Malone** is an Associate Professor in the Department of Industrial Engineering and Management Systems at the University of Central Florida. Dr. Malone received her Ph.D. in Statistics from Virginia Polytechnic Institute and State University in 1975. She joined the faculty at the University of Central Florida in 1979 after four years at Mississippi State University.* ✪

Artificial Intelligence (AI) and Simulation Workshop

The fifteenth National Conference on Artifical Intelligence (AAAI-98) will hold an AI and Simulation Workshop as part the conference program. The workshop will be held during 26 - 31 July, 1998 meeting in Madison, Wisconsin. For further information contact **Dick Modjeski** (Chair) at worldnet.att.net or **Tom Shook** at tshook@mindspring.com.

What Every Good OR Analyst Should Know About Bayesian Networks!

Lieutenant Colonel **Dan Maxwell**
JWARS
OSD(PA&E)

Two things are almost always true when a military leader or a civilian policy maker asks military operations researchers to assist in addressing issues and decision problems. First, the leader cares about the problem for more than one reason. Normally, these reasons are connected with a highly complex set of relationships. If thinking the problem through was easy he or she would just complete an intuitive analysis and make an appropriate decision. Second, the future can not be predicted with certainty. Uncertainty is a fact of life, particularly in the area of military operations research.

The Bayesian network is an emerging modeling technique that provides OR analysts and computer scientists a new and extremely powerful mechanism for integrating necessarily informal model construction techniques with the formalism required for computationally generated inference under conditions of uncertainty. Bayes Nets are currently being applied successfully to many important analytical problems, including some military problems. Additionally, Bayesian networks are often found embedded into larger scale decision support systems and artificial intelligence applications (see Table 1). Readily available commercial software packages have capitalized on recent advances in graphical displays, computational algorithms, and computer processing speed. These packages support rapid construction of complex Bayes network models. This has led to rapid increases in the variety and practicality of such models. Soon, they will become another standard tool of military operations analysis.

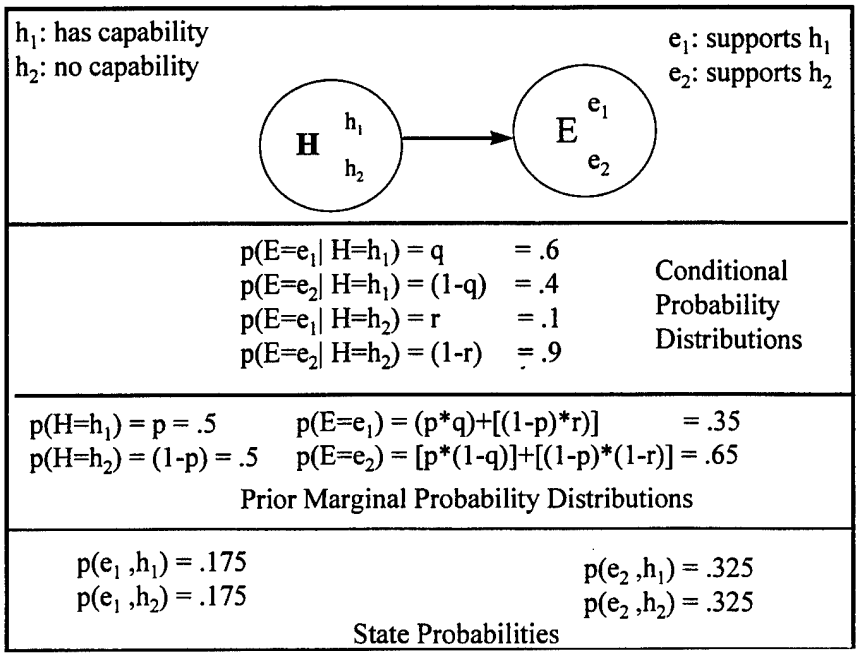

Figure 1. Fully Specified Bayes Network (Prior)

This introduction to Bayesian networks briefly answers the following questions: What is a Bayesian network? What are they good for? How can I find out more about them?

What are Bayesian Networks?

A Bayesian network is a set of interdependent Bayesian inferences. That is, some inferences in the model depend on knowledge that is encoded elsewhere in the model. The relationships in these models are often complex. To deal with these complexities Bayesian networks are normally formulated using graphical techniques that make it simultaneously understandable to a human formulating the model (like a domain expert) and to a computer for mathematical computation. Some researchers in the field refer to Bayes nets as knowledge maps[1], belief networks, or causal networks.[2]

The computational foundation for Bayes nets is Bayes Theorem. That theorem states that:

$$\Pr(Hi \mid Ej) \propto \Sigma \Pr(Ei \mid Hj) \Pr(Hi).$$

In other words, it says that the probability (belief) associated with a hypothesis (H_i) may change as evidence (E_j) is collected. That change is proportional to the sum of the probabilities that one will observe the evidence when the hypothesis is true. Figure 1 is an example of a fully specified, albeit very simple, Bayes net. The nodes

(See **NETWORKS,** *p. 26)*

Table 1: Sample Uses of Bayesian Networks

Used by	Purpose
Microsoft	Windows 95 online troubleshooting
Selected intelligence agencies	Sensor fusion
Medical laboratories	Disease diagnosis from test results
Oil companies	Oil price forecasting

(continued from p. 25)

represent variables in the model and the arcs identify relationships that may exist among those variables. The relationships are expressed in the model as conditional probability distributions or possibly deterministic functions. Information concerning these relationships is often collected from experts. However, it could also be collected through physical tests and experimentation, historical data, or as an output from a simulation model. This particular network represents a joint probability distribution involving the variables H and E. It has four states. This is referred to as a prior distribution because it identifies the level of belief associated with the model variables before evidence is collected.

Imagine a hypothesis (H) concerning a potential aggressor nation's possible possession of nuclear weapons. We begin with the likelihood of the possession of these weapons as a "toss up." This is reflected by assigning a probability of .5 to each possibility. Our nation collects evidence (E) from various sources that affect the belief that a nation possesses these weapons of mass destruction. The meaning of this evidence is often uncertain. This is why conditional probability distributions are used. For example: If we observe e_1 it increases the belief that a nuclear capability exists. This is identified as a probability of .6. However, there is a 40 percent chance that e_1 could be observed even if there was no nuclear capability. Conversely, e_2 could be observed if a nuclear capability exists, but only ten percent of the time. Ninety percent of the time e_2 would correctly indicate that the nation did not possess a nuclear capability.

Unfortunately we cannot directly observe the hypothesis. We observe evidence. In this case pictures, intelligence reports, and other sources might serve as relevant evidence. The information in Figure 1, plus an observation of the evidence, and Bayes theorem provide the three keys to rationally adjust our belief in H. Figure 2 demonstrates how this works. Once e_1 is observed to be true, application of Bayes rule increases the belief associated with h_1 significantly. These probabilities associated with H are now called "posterior" distributions.

This example is so elementary that it could easily be solved without elaborate

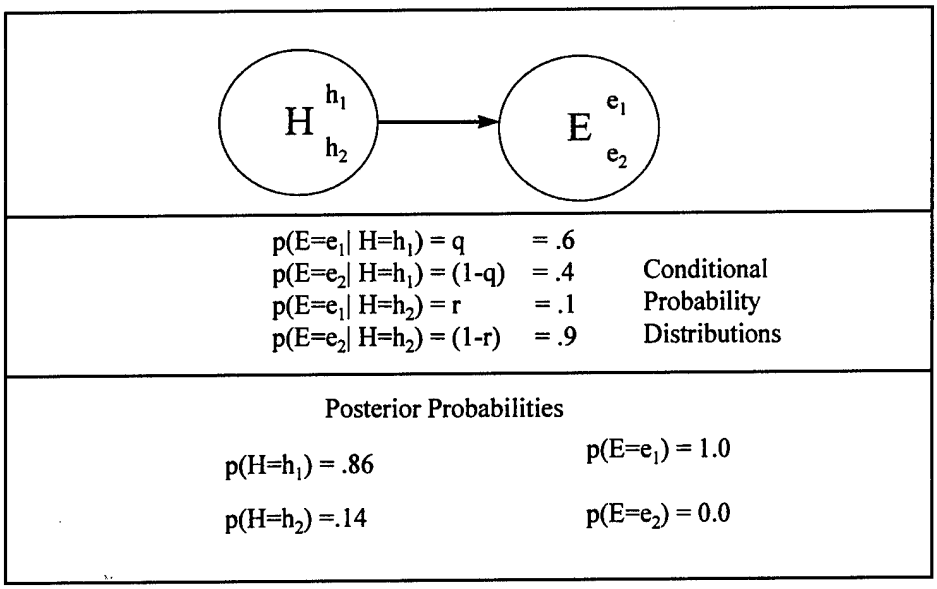

Figure 2. Posterior Bayes Network

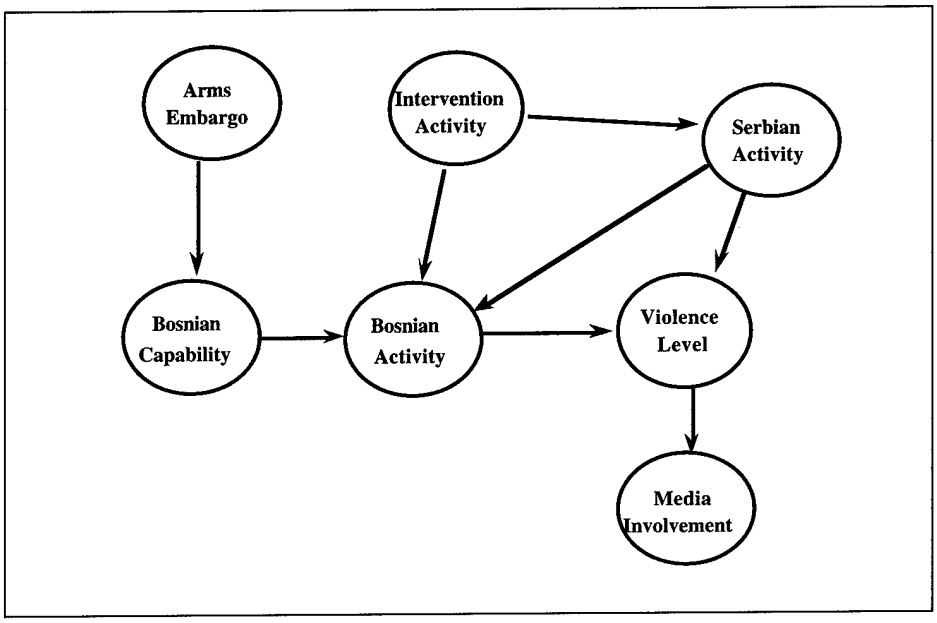

Figure 3. A more complex Bayes net

computational assistance. There is no requirement to hierarchically apply Bayes theorem to interdependent inferences or to integrate multiple sources of information. There are few real-world situations, however, that are so obvious. Figure 3 is an example of a slightly more complex network that illustrates what can happen when interdependent inferences and multiple information sources are introduced. This model has only seven nodes and eight arcs (It is also a simple prototype). If one assumes that each node has two states, there could be 127 (2^n-1) probabilities that would require elicitation. Fortunately, the structure of the problem, as expressed by the eight arcs in the graph reduces the elicitation requirement to 18 probability judgments. In general this elicitation savings continues to grow as the networks get larger.

There are two types of applications for which Bayes nets are particularly well suited. The first type of application is diagnostic. What should I believe about the world, given the evidence I have collected? The question concerning ownership of nuclear weapons is of this type. The second appli-

cation is for predictive modeling. Given a set of events (evidence), what is the likelihood that something will happen? The sample network in Figure 3 is an example of this type. In both instances, information developed through exploratory modeling on Bayes nets is easily extended into Decision Diagrams that can be modeled using other decision analytic techniques and software.

Bayes nets are not, however, a modeling panacea. In some situations analysts can rather easily "outsmart" themselves. First, Bayes nets (and Bayes net software) are not usually the best vehicle for collecting expert input regarding uncertainty. There are other techniques and commercially available software for accomplishing that task. Second, in conditions where the uncertainty surrounding the uncertainty is high, Bayes nets can give the "illusion of accuracy" by using a computationally complex model. In such cases analysts may want to resort to simpler methods. Finally, situations that have a very significant temporal aspect can be difficult to capture in a Bayes net: the joint probability distribution that is formed is static. Therefore, temporal relationships must be provided as part of the model formulation process. This very often results in computationally infeasible models because of the complexity of these relationships.

There are a myriad of subtle, but very important, issues that must be considered in the development of all inferential models. The challenges to building good Bayesian networks identified here are also challenges to varying degrees for all other inferential modeling techniques. Interested readers should refer to research in the areas of evidence, intelligence modeling, and descriptive decision theory.[3,4]

Where is there more information?

There are a number of ways to learn more about Bayesian networks. One could read the literature, surf the net, or experiment with modeling in a commercially available software package.

There is also a continually growing array of software available for processing Bayesian networks and influence diagrams. A review of many of these packages is published annually in *OR/MS Today*.[5] Additionally, the INFORMS Decision Analysis Society maintains a web site that provides links to the current literature and software sources. The address is http://www.informs.org/Society/DA.

A list of references that address Bayesian networks, with the audience it would appeal to is:

Source	Audience
Decision Analytic Networks in Artificial Intelligence, **Matzkevich** and **Abramson**	Introductory. A must for programmers. (Has a great reference list.)
Influence Diagrams, Belief Nets, and Decision Analysis, **Oliver** and **Smith**	Intermediate to advanced. For analysts who will be constructing models.
Probabilistic Reasoning in Intelligent Systems, **Pearl**	Intermediate to advanced. For analysts who will be constructing models.
Probabilistic Reasoning in Expert Systems: Theory and Algorithms, **Neapolitan**	Advanced. For those who want to know what makes something tick.
Supporting Decision Makers in Future Conflicts: A Decision Theoretic Perspective, **Maxwell**	Introductory. For the decision maker or analyst who is unfamiliar with Bayes nets. (includes a discussion of influence diagrams)
Influence Diagrams, **Howard** & **Matheson**	Introductory to advanced. This is the seminal research article.
Bayesian Networks Without Tears, **Charniak**	Introductory, Mandatory reading

Acknowledgments

The author gratefully acknowledges Dr. **Robert Helmbold** of the US Army Concepts Analysis Agency and Professor **Dennis Buede** of George Mason University for their assistance in the preparation of this article.

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Biography

*Lieutenant Colonel **Dan Maxwell** is currently a senior operations research analyst and the US Army representative at the Joint Warfighting System (JWARS) Office in the Office of the Secretary of Defense, Program Analysis and Evaluation Directorate. Prior to joining OSD, Dan was assigned to the US Army Concepts Analysis Agency and provided analysis in support of many DoD studies. He holds a Ph.D. in Information Technology from George Mason University, an MBA from Long Island University, and a B.S. in Criminal Justice from Rochester Institute of Technology.* ✪

CAA to Celebrate Silver Anniversary; All Alumni Invited

E. B. Vandiver III
Director, US Army Concepts Analysis Agency

On 15 January 1998 the US Army Concepts Analysis Agency (CAA) completed its first twenty-five years of providing responsive analysis support to Headquarters, Department of the Army and other Army decision makers. The CAA Silver Anniversary will be celebrated at the annual Anniversary Dinner Dance on 25 April 1998 at the Fort Myer, Virginia, Officers Club.

CAA was created in the 1973 post-Vietnam reorganization of the Army that went under the name Project STEADFAST. In this reorganization the previous Continental Army Command (CONARC) and the Combat Development Command (CDC) were realigned. Combat developments was strengthened by combining it with training in the Training and Doctrine Command. The span of attention of CONARC was reduced by creating a new Forces Command that was to focus solely on the readiness of Army Forces. Thus from CONARC and CDC the Training and Doctrine Command (TRADOC) and the Forces Command (FORSCOM) emerged.

STEADFAST also centralized operational testing and force analysis through the creation of two new Headquarters, Department of the Army agencies: the Operational Test and Evaluation Agency (OTEA) for operational testing and the Concepts Analysis Agency (CAA) for force analysis.

The driving intellect behind STEADFAST was the late General **William E. DePuy** who at that time was Assistant Vice Chief of Staff of the Army. That the organizational realignments of STEADFAST have now endured for twenty-five years is a tribute to the incisive insight and far reaching foresight of General DePuy.

Much has changed at CAA over twenty-five years but essential core values have endured. CAA had a peak strength of about 325: it is now authorized 178. CAA once did mostly studies of some length (9 months to 1 1/2 years) with manpower loading counted in man-years. It now does preponderantly quick reaction analyses that take days, weeks, or a few months and commensurate manpower. CAA once focused almost exclusively on analysis of the Central Front in Germany: it now conducts analysis ranging over all areas of the globe. CAA once almost exclusively supported the Office of the Deputy Chief of Staff for Operations and Plans: today CAA supports a broad spectrum of Army decision makers in both Headquarters, Department of the Army and Army Major Commands. CAA once had a single giant computer, and now has a dedicated com-

(See **CAA,** *p. 29)*

Lessons Learned and Future Directions Mini-Symposium and Workshop, 7-9 April 1998

The legislation that mandated the 1997 Quadrennial Defense Review (QDR) calls for another QDR in 2001. The military analytic community can improve the quality of the analysis supporting the next QDR by drawing upon the lessons of the last one.

With this in mind, MORS has organized a Mini-Symposium and Workshop to address the question of "QDR Analysis: Lessons Learned and Future Directions." It will be held at The Johns Hopkins University Applied Physics Lab in Laurel, Maryland

The Mini-Symposium on April 7th will consist of presentations by high-level decision makers from OSD, the Joint Staff, the Services, and Congress — as well as a member of the National Defense Panel and several experienced outside observers. These presentations will reflect upon the lessons that can be drawn from the 1997 QDR process and will also look to the future.

The Workshop on 8-9 April 1998 will consist of working groups to explore ways of improving the analysis that underlay the major topics of the QDR. There will also be presentations on alternative ways of thinking about the problems addressed by the QDR.

Participants may attend just the symposium on 7 April. All participants in the 8-9 April workshop should also attend the 7 April symposium.

MORS, as the professional association of military analysts, hopes that this gathering will identify actions to be taken and research to be carried out over the next 30 months that will improve both the intellectual quality and the value of the next QDR.

For further information on the Mini-Symposium/Workshop, checks the MORS web page at www.mors.org. Or you can e-mail (morsoffice@aol.com) or call (703-751-7290) the MORS office to request an application packet. ✪

CAA

(continued from p. 28)

puter (or two) on every analyst's desk networked throughout CAA, the Army and the defense community. The one thing that has not changed is CAA's unwavering dedication to providing the Army's top leadership with responsive, high quality analysis support.

To our Silver Anniversary Celebration we are inviting the STEADFAST personnel involved with the creation of CAA, the DA Staff personnel who created the original plans for CAA, the CAA Implementation Planning Group, and all the previous senior leadership of CAA. All CAA Alumni are invited to come join in our celebration. For information and reservations contact Ms. **Renee Carlucci** at (301) 295-5270 (e-mail: carlucci@caa.army.mil); or Mr. **Neal Siegel** at (301) 295-5255 (e-mail: siegeln@caa.army.mil), or FAX (301) 295-3874. ✪

SIMTECH 2007 – Session 2

The Organizing Committee for Simulation Technology (SIMTECH) 2007 has decided to postpone the second Workshop, which had been scheduled for 5 - 7 March 1998. There are several reasons for the postponment:

- It has taken longer than anticipated to document fully the deliberations of the first workshop (which was conducted 16 - 18 December 1997). It was deemed important to capture and convey the results of that meeting to establish a firm foundation for the second Workshop.
- It became apparent that the previously scheduled dates for the second Workshop were inconvenient for a number of key participants (e.g., academics; individuals involved in other M&S community activities).

Consequently, the second Workshop has been tentatively rescheduled for 11 - 13 August 1998. The location for that Workshop is to be announced. ✪

The Military Operations Research Journal Call for Papers

Special Issue of Military Operations Research on **Warfare Analysis and the New Sciences**

In September 1997 MORS held a Mini-symposium/Workshop on Warfare Analysis and Complexity. The Mini-symposium drew 165 participants who were enthusiastic about the use of New Sciences in military operations research. The recent article in *PHALANX* summarized much of the discussion regarding the applicability of the New Sciences to problems in military operations research. We want to expand the discussion and consider technical applications of the New Sciences to specific problems in operations analysis. The special issue of *Military Operations Research* will be focused on this topic. The purpose of this special issue is to assess, clarify, and discuss the effectiveness of novel New Sciences techniques and to propose improvements to military operations analysis.

The New Sciences are meant to include chaos and complexity theory, edge of chaos, complex adaptive systems, and more generally, any techniques for rapidly scanning the solution space of a computationally complex problem in order to determine boundaries of behavior and regions where rapid changes occur. All papers will be unclassified. In accordance with *MOR* editorial policy, we require certification from a senior decision-maker when applicable.

Interested authors should submit **abstracts** by **31 May 1998** and **papers** by **30 September 1998**. The papers should be submitted in accordance with our current editorial policy. All papers will be refereed.

Please contact me if you are interested in authoring a paper for this special issue.

DR. JULIAN PALMORE
Guest Editor, *Military Operations Research*
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Announcing MORS-TRAC Open House: TRADOC Analysis Center (TRAC) – Monterey

Need a break from the 66th MORSS? Come visit TRAC-Monterey's open house! All MORSS attendees are invited to see cutting edge computer simulation demonstrations, learn about TRAC projects, and learn about the history of TRAC-Monterey. The open house includes daily demonstrations of constructive combat simulations in stand alone and distributed modes. Hands-on opportunities to build and fight battlefield scenarios using the Janus high-resolution simulation. Fly the NPSNET virtual helicopter against hostile Janus entities. Don't miss this exciting opportunity to experience what the US Army TRADOC Analysis Center is all about! It will be held daily 23-25 June from 1200-1330 (refreshments will be provided). For Details contact SFC **Chris Augustine** at (408) 656-3086/4059 or by e-mail at augustic@mtry.trac. nps.navy.mil.

MORS PRESIDENT

(continued from p. 3)

established. The Board agreed. The new officer, the President Elect, will automatically succeed to the office of President at the conclusion of the annual symposium held a year after her/his election. Also, the Board voted to hold election for the new Executive Council and new Board members at a Board meeting on Sunday — a day earlier than the past Monday election meeting. This earlier election should provide for committee assignments to be completed sooner and for the new Executive Council to interact more with members during the symposium. Both of these new initiatives were designed to improve the Executive Council transition and provide better focus on the future vision of MORS. Although the duties of the President Elect have yet to be defined exactly, it is anticipated that the Strategic Planning Committee will report to the President Elect. Also, the President Elect will participate in the Sponsors' luncheons — both at the annual symposium and mid-year at the Pentagon. If anyone has any ideas for the structure of this new office, please send them to the MORS office. (This June will see a unique MORS election. Both a President and President Elect will be elected by the Board — details and procedures are still being defined.)

Other actions are envisioned that will also improve transition and help strategic planning. One is that committee assignments will be posted on the MORS Web page in July. A second is that committee POA&Ms will be posted in August and reviewed by the Executive Council at their September meeting. This will also help our future volunteers identify areas where they can help. The complete set of POA&Ms for the Executive Council and their committees should help focus our MORS strategic vision. A second action is a MORS President's Open Forum will be held in the Washington area — a lunch or dinner (Dutch treat) at which the President (and possibly candidates for president and president-elect — to be determined) will answer questions, share visions, accept recommendations, and hold discussions with anyone interested in MORS. But, as we continue to make recommendations and take actions to change the MORS strategic plan, we must remember the need to protect the MORS "niche" — the capability to hold classified meetings in areas of military operations research.

One of the past actions the BOD has taken to ensure MORS remains focused is to elect members that have "made a difference to MORS" as Fellows of the Society. This year the BOD chose three new Fellows: **Vern Bettencourt**, FS, **Chris Fossett**, FS, and **Jackie Henningsen**, FS — all of whom so richly deserve the recognition based on their prior actions and dedication to MORS.

The challenge to keep MORS strategically focused has been discussed. Now it is time for members and volunteers to plan ahead. In the near term, plan to attend the next MORSS to be held at the Naval Postgraduate School, Monterey California, 23-25 June 1998 and participate in "Preparing for Military Operations Research in the 21st Century." In the far term, plan to set goals and take actions to keep MORS and military operations research relevant. ✪

VEEPS PEEP

(continued from p. 5)

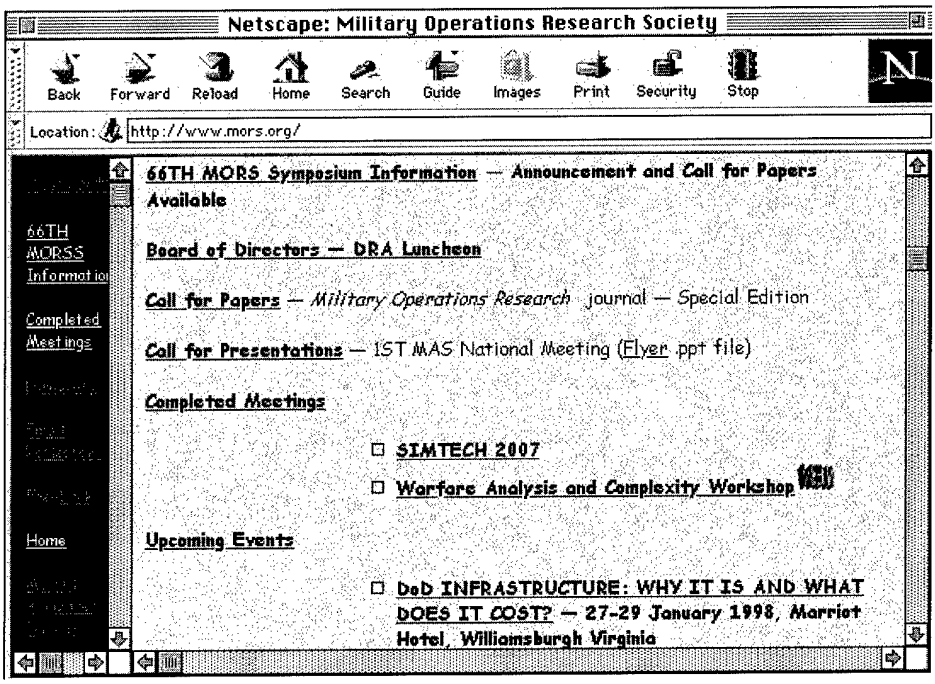
relevant information to the membership.

Akin to the "pull" of information from the web has been the use of e-mail and mailing lists to "push" caplets of information across our membership. This, too, is a capability that has exploded in the recent past. Information technology is no doubt having an impact, in helping us become much more efficient and knowledgeable, in helping the Society to accelerate the exchange of our 'lifeblood'.

Vision — the Shared Identity

The final key area critical to the preservation and growth of our Society is the vision. The vision is "the invisible field" which enables our organization to have a shared identity, to ensure we are on the same playing field as we move ahead. Key to this has been the Re-Engineering of our Composite/Working Groups and our very active strategic planning process. The recent decision of the Board of Directors to elect a President Elect, who will lead the strategic planning process the year preceding his or her term as President, will further strengthen our Society in this critical, life sustaining area.

In summary, the MORS vital signs are healthy. We look forward to turning the millennium with strong Sponsor support and a renewed enthusiasm from within our membership. We are preparing ourselves for the 21st Century! ✪



QUICK RESPONSE

(continued from p. 11)

Thanks to the vision of Laughlin's leaders, there was never an issue of visibility, or support of the project. For example, immediately upon the team's arrival at Laughlin, the Group Commander convened a discussion session including every Squadron Commander, as well as the Maintenance Chief (civilian contractor) to fully explain their concerns and answer questions. Many factors affected pilot training capacity including classroom space, housing, and numbers of instructor pilots. Increased funding could solve most of these problems, but the fundamental limitations of runway capacity and airspace limitations could not be solved quickly with increased funding. Environmental studies for changes in airspace usage alone could take years; therefore, existing airfield operations would be the focal point for the project.

Clearly runway and airspace resources would dominate the analysis. Laughlin AFB has three runways. The T-37s use one runway and the T38s and T-1s share the other two. All students complete T-37 training and then move on to the T-38 (for fighter/bomber students) or the T-1 (for tanker/transport students).

Initial problem framing quickly narrowed to T-37s for several reasons. First, the T-37 squadron generated the most sorties in the Wing. The T-38 squadron trained only a fraction (20-40%) of the students, and the T-1 squadron did much of its training off-station. Second, modeling the T-38s and T-1s could not be done independently since they share runways, often simultaneously, and have distinctly different operating characteristics (e.g. operating airspeeds and pattern procedures). Due to the interdependence between the T-38s and T-1s, a quick analysis would be impossible. Since time was of the essence, it was decided that a realistic T37 model would be far more valuable than an incomplete, complex model of all aircraft interactions. In addition, with a single runway and high number of local sorties the team (and Laughlin leadership) intuitively believed that the T37 operation would be a constraining factor in the operating environment. Therefore, the analysis focused on T-37 operations. If we could verify that the T-37 would be a bottleneck in the quest for the planned 1100 pilot production level, we would at least prove that significant changes would be needed to meet overall production goals.

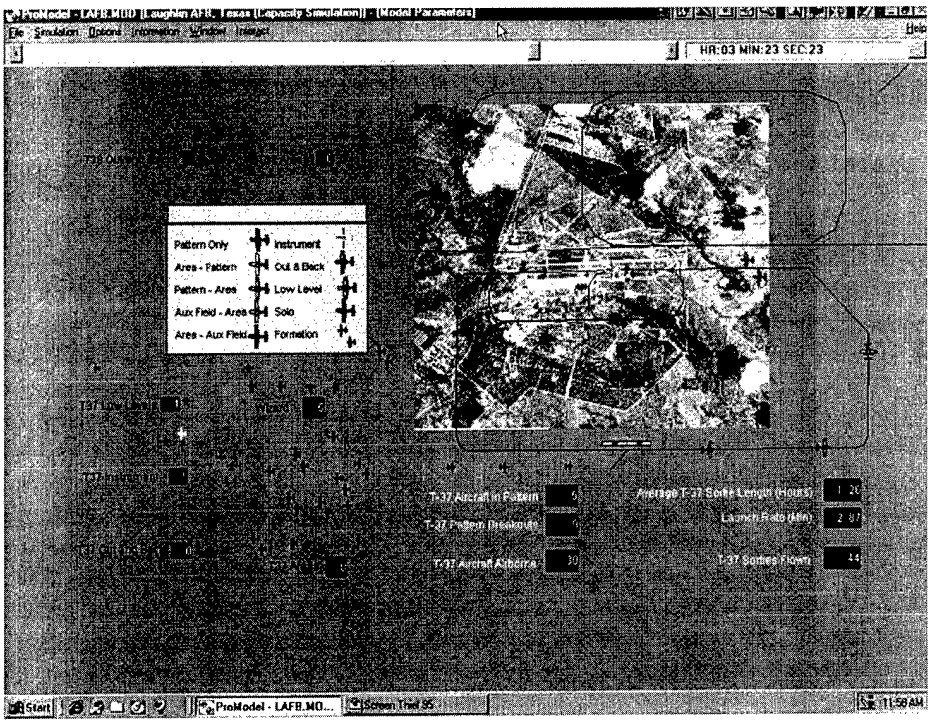


Figure 3: ProModel Display (Note: traffic pattern is drawn to scale and overlays a satellite photo of the airfield)

Building the Model

We began building the model by observing the airfield operations. Preliminary data gathering, such as taxi times, takeoff delays, and pattern times began. The team then went back to the Academy to complete the work. Laughlin agreed to provide further data as requested. Working a thousand miles from Del Rio, TX was not ideal, but little about this project was.

We used Pro Model software for this project due to its ease of use and familiarity. Every operations research student at the Academy uses this software in an introductory simulation course. A key member of our team, Second Lieutenant Brian Rizzoli was a recent OR graduate of the Academy and had experience with the software package. Lt Rizzoli accomplished all of the programming for this project.

The team started by looking at the airfield and its surrounding airspace. Because Laughlin AFB is in rural Texas, the base has a rare luxury in today's environment: plentiful airspace. This then focused our attention on the traffic pattern operations. Although, we could not eliminate the training areas completely from the model, we decided to model the 23 training areas simply as placeholders. Another key issue was whether to model for weather and maintenance attrition. Since Laughlin had years of historical attrition data, we decided to model for perfect conditions. Once we had a "perfect condition" capacity, Laughlin could add in the attrition factors to get realistic annual sortie production.

The T-37s actually use two runways for their operations, one at Laughlin AFB and an auxiliary field about ten minutes flying time from Laughlin. The pilots refer to the auxiliary field as "Wizard," and we used this designation in the model also (see Figure 3). The operations of the two runways are almost identical and once we had a model built for one runway, it would take very few modifications to build a model of the second runway's operations.

In order to model the T-37 operations we had to understand the types of profiles that were flown and the number of sorties. There were four basic types of sorties called for in the UPT syllabus: contact (basic flying), instrument, formation, and navigation. Each sortie has its own profile with slight variations. Once we analyzed the data provided by the T-37 squadron we came up with nine sortie profiles. Laughlin also provided us with the percentage flown of each type of sortie. From this

(See **QUICK RESPONSE,** *p. 32)*

(continued from p. 31)

data we could build the typical sortie profile. For example, one sortie might do pattern work first and then go to an area while another sortie might reverse the order.

Once we had the sortie profiles, we could concentrate on the actual operations of the aircraft in the air and on the ground. The primary concern now was conflict resolution. We knew the general flight paths of the aircraft, but we had to have solutions when two aircraft tried to occupy the same space at the same time. Even more than this, we had to apply these conflict resolution procedures when two aircraft got too close to each other. To do this we built a 3000 ft. buffer around each aircraft. When the buffer was violated, the aircraft with the lower priority according to the "rules of the road" had to breakout from the pattern. These breakout procedures came straight from the pilot's operating procedures and were straight-forward to implement.

We added in the ground operations for queuing and taxi procedures and from here we had a workable model (see Figure 3). This initial design process for the model took about a month for us to design. Again remember, this is a part time project for the design team.

Problems

One of the first problems we encountered, after the shell of the model was built, was deciding on an appropriate variance for airspeed control. Initially the aircraft moved around the model at a discrete airspeed determined by the operating regulations. However, we knew that pilots do not maintain a given airspeed exactly, especially in a training environment. We decided to use a normal distribution for airspeed, but we needed a variance. Our first attempt at determining a variance, was the "old fashioned" way. We had an observer go out to the runway with a stopwatch and time various pattern operations. There were three problems with this approach. First, determining an exact point in space on which to start and stop timing was next to impossible. Second, the pattern was not operating at anywhere near capacity at the time. When the pattern is empty, the instructor pilots will let students make more mistakes and vary from their assigned airspeed more than when the pattern is full. Third, when the pattern is operating near capacity pilots will make adjustments to keep their spacing when at all possible. When we reviewed the observation data we got a very large variance. It is common to have these problems when observing a system that is lightly loaded and then trying to extrapolate the data to a system under maximum load.

We knew that our data was suspect and decided to tighten the variance based on trial runs that seemed realistic to both Laughlin pilots and the team. We also designed the model such that the variance for airspeed and some other parameters was an easily changeable variable in the model. This model design allowed us to test the sensitivity of the model to the variance and alter the model if we were able to get better variance data in the future. This was not an ideal methodology, but given the time constraints and the lack of a near capacity operation to observe, we made the compromise. The eventual variance we decided upon was 8%.

A second problem was deciding what was an acceptable quality level for each sortie. For example, we could increase the launch rate so that the average wait time for takeoff was an hour. Given the fuel and training restrictions this meant that the sortie might last only 20 minutes instead of the planned 1.2 hours. The final solution to this problem was to make many of the quality indicators outputs for the simulation. This way the Laughlin leadership could judge for themselves whether a given launch rate was feasible.

Assumptions

12.0 hours daylight
11.2 Hour Launch Window
Minimum Sortie Length - 1.05 Hours
Variance - 8%

Results (Average of 5 Simulation Runs)

Step Rate (planned takeoff interval	*2.5 min*	*2.8 min*
Total Sorties Flown	270	290
Average Sortie Duration	1.28 hours	1.33 hours
Breakouts (conflict resolution)	73	95
Max Aircraft Airborne	32	39
Max Aircraft in Pattern	10	13
Avg Number of Landings	6.07/sortie	3.08/sortie
Max Wait for Takeoff	11.0 minutes	32.1 minutes
Average Wait for Takeoff	5.2 minutes	16.3 minutes

Figure 4: Simulation Run Statistics

The Finished Product?

By mid-March we presented the T-37 model to Laughlin. This was about three months after we began this part-time project. To date Laughlin has run over 300 simulations since receiving the model. We have not decided whether to pursue the other half of the model (i.e. T-38/T-1 operations) since the model already shows significant capacity shortfalls in just the T-37 operations. The typical launch rate we achieved was in the range of a sortie every 2.8 minutes (see Figure 4 for typical simulation run statistics). From the simulation run statistics you can see that although the number of sorties flown increases with increased step rate, the quality statistics go down significantly. Specifically, takeoff-wait increases and number of landings per sortie decreases (a maximum number of landings is essential for quality training in the UPT environment). This is significantly less than the previous estimate of a sortie every 2.5 minutes.

Conclusion

Due to this study and other indicators, AETC is currently looking at other ways to ease the capacity problem at its three primary UPT bases. Some of these options

include: going to single aircraft operations for each base (i.e. all T-37s at one base, etc.); moving T-1 operations to a new base; and possible using Randolph AFB for some pilot training operations. No decision on an acceptable resolution for this issue has been made to our knowledge. Providing a solution to the problem was not our goal. Our goal was to give Laughlin a tool that they could use to estimate their true training capacity (and, by the way, do it quickly). In this goal we succeeded. Here are a few of the key points that made our quick-response project possible:

1. We were able to narrow the scope of the project quickly by establishing likely bottleneck points.
2. We had an operational expert (former T-38 Instructor) on our design team.
3. An exact solution was not needed (i.e. the total capacity for the base). The user only wanted to validate the hypothesis that the training capacity would fall short of projections.

Obviously, every project will not be suitable for this quick response approach. However, under certain circumstances, a simulation may be an appropriate response for a problem that needs a quick answer. With today's modern software tools, simulation is moving into the mainstream for many projects that were not feasible for this approach in the past.

Biographies of the Authors

James K. Lowe *is an Assistant Professor of Management at the U.S. Air Force Academy. He retired from active duty as a Lieutenant Colonel this year. Dr. Lowe earned a Ph.D. from the Georgia Institute of Technology and currently teaches advanced courses in Operations Research at the Academy.*

Captain ***Michael R. Weeks*** *is an Instructor of Management at the U.S. Air Force Academy. He earned Master of Business Administration and Bachelor of Electrical Engineering degrees from Auburn University. At the Academy, Capt Weeks teaches Management Information Systems courses and instructs cadets in basic flying skills in the T3A Firefly. Capt Weeks is a senior pilot with over 3300 hours flight time in C141, T38, and T3 aircraft.* ✪

ANALYSIS

(continued from p. 1)

cult to describe. Allied and coalition operations predominate, yet none are certain *apriori*. We as a Defense culture simply face a bewildering mix of complexity. The central issues are simply not as clear as they used to seem.

The first and most important job of the analyst is to get the questions right. My Dad once told me that if the answers I was getting weren't solving my problems, then maybe I was asking the wrong questions. I see a lot of answers being generated by studies today, but I also see us asking the same questions over and over in repetitive studies like DAWMS and MRS, BASE FORCE, BUR, QDR, WMD, CBMR. That leads me to think that maybe we haven't got the questions right yet.

It's no surprise. The issues we face today are so new and complex that I suspect that frequently the decision makers aren't that sure what it is they need to ask. The analyst needs to be diplomatically aware that initial analytic tasking can be just a desperate stab at a general lack of insight, and as such can be somewhat removed from the underlying central issues, the "real question."

Always, "Look before you leap." If the analyst jumps to answer the questions as they are first asked today, he or she runs a real risk of producing irrelevant analysis. I consider it an analyst's obligation to question the question.

How can an analyst discover the right questions? On the Joint Staff, we are using seminar gaming with the real decision makers as a "front end" to the quantitative analysis. The evolving experience is that any analysis can benefit by engaging the decision makers and stakeholders early in the design phase of the analysis.

There is an important point to be made here. "Knowing your customer" means more than knowing "who" is chartering the study. It means helping the stakeholders and decision makers discover what it is they really need to know. And it means doing that before you design the study methodology.

Seminar gaming is proving to be an excellent method for discovering the real questions that underlie the issues. With increasing frequency, we are using seminar gaming as a front end to our quantitative analyses. We get the stakeholders and decision makers to the table; immerse them in a scenario containing their initial issues and have them work through that scenario to a better understanding of what they are really interested in. In this way, we and they discover what it is about the general issue that is really important, what the range of viable solution actions might be, and how the important relationships and measures might best be presented to them. In this way, seminar gaming at the front end of the analysis helps us cover the first three steps of the analysis recipe; "What's the Question," "What's the Real Question," and "What do the Final Slides look like."

The Third Step in the analytic process, "What do the Final Slides Look like?" — may need some clarification.

Understanding what the final slides must look like does not mean to suggest that the analyst has the "answer" before he does the analysis. It means that he must know which key relationships and perspectives need to be presented to illuminate the "Real Questions." With this view of the final slides, the analyst can determine what data enables those relationships and perspectives to be developed. Once an analyst knows what the real questions are and how to present key relationships, it is not uncommon to discover that most of the data needed already exist.

The Fourth Step in the analysis recipe, "What do I already know?" — is the Literature Search phase of the analysis.

The literature search may be the most misused of the analysis recipe steps, because if it is done at all, it is often done as the second step in an analysis process right after, "What's the Question?" And, unfortunately it may be done not to discover what is already known about the key relationships, but to see what other analysts may have done to answer the initial question. There is a false safety in those precedents. Yesterday's methods and answers may be of little help in illuminating today's central issues. When the literature search is done as the fourth step in the analysis process, the analyst knows what to look for, why it's needed, and how to use it.

(See **ANALYSIS,** *p. 34)*

ANALYSIS
(continued from p. 33)

The Fifth Step, "How do I get the remaining information I need?" comes into play when data to fill in the final slides aren't available and must be generated.

This step may be where an analysis is most likely to become irrelevant.

More than any other time I can recall, the Defense Analysis community seems to have become excessively "Model Centric" in its behavior. Too often the first thought from the analyst when faced with a tasking is, "What model do I use?" To make matters more dangerous, there is an extensive culture of (Modeling & Simulation) M&S advocates, committee bureaucracies, and VV&A safeguards encouraging the analyst toward Model Centric thinking.

Analysts were once valued primarily for the way they thought. The current emphasis toward model centric analysis almost encourages the analyst not to think. The perception is growing that with enough improvement, models will become, "bozo proof" — meaning that one won't have to think much in order to use them and produce what can pass for sound analytic insight. After all, if the data are blessed, and the Model is VV&A'd, then anyone can turn the crank and produce insights. Maybe most dangerous of all is that senior decision makers are beginning to think that using a trusted model equates to generating a quality analysis. Such thoughts can be dangerous. A better model improves the analysis only if the analysis process is correct for the issue being examined.

How can analysts overcome model centric thinking and make their analyses more relevant? For one, they can follow an analysis recipe such as enumerated here. But there is one more basic principle that can help. That principle is "Collaboration."

Collaboration is more than coordination. Collaboration acknowledges that good analysis has at least two important functions. One, of course, is to help the decision maker better understand the issues and to appreciate the consequences of potential decisions. The other important function, which analyses many times fails to do, is to help prepare the stakeholders to implement the decisions when they are made. Collaboration supports both of these functions.

Collaboration engages stakeholders in the design and the execution of the analysis. It recognizes that there are many potential views and interests in any complex issue and that the best experts and tools in these interests are usually in the hands of the stakeholders. As an example, it would be better to engage the lift community and their models directly in the transportation aspects of a global warfare capability analysis than to run one's own model based transportation analysis. Even if the analysts use the same tools, if the transportation expertise wasn't collaborating in the design and execution of the analysis, the analyst could readily expect that when the study was done and offered for coordination, those he ignored would arrive at his work with drawn knives and debate and/or counter the findings rather than help the decision maker implement any decision coming from the work. Community ownership is an important element in most relevant analyses. Collaboration can provide that sense of ownership.

In short, without collaboration, all a major study is likely to give the decision maker is a bigger debate; and another irrelevant study. Unfortunately that resulting debate frequently takes the form of an attack on the analyst's model. That leads the decision maker, in frustration, to give direction to "fix" the models, instead of to a decision on the real questions. This, then, further fosters the notion that a better model will lead to a better analysis; more model centric thinking. The model may have been fine; it was the analysis process that needed fixing.

Even if the model gets "fixed," and that can be expensive (try the better part of $100 million for JWARS), if the next analysis uses the model in isolation from the stakeholders, the resulting analysis could easily just generate another model centric debate. Sadly, the more one spends to "fix the model" the more one is obligated to use it on the next analytic question — still more model centric encouragement. It's insidious. The analyst must not become wed to his tools. He has to be prepared to say, "no" to even the most vigorous Model Centric pressures if the models don't fit the analysis design at hand.

I agree with those who argue that better models are desirable. But, I do not believe that better models, by themselves, will give us better analyses. The path to relevant analyses lies in better analysis process and collaboration, not just with better models.

These thoughts on collaboration and use of an analysis recipe may have significant implications for the new JWARS model and its ability to improve joint analysis. My sense is that the "stronger" a model is purported to be and the more universally it is endorsed, the greater the temptation is to use it in isolation; "Why do we need to involve them? The model already represents how they do their part." Doing analysis in noncollaborative ways sets the stage for studies becoming irrelevant, regardless of how robust the model that was used.

So, what's the bottom line here? It is this. Relevant studies tend to address two key areas; increasing capability and decreasing costs. A study can be made more relevant by making it "actionable," that is that it encourages specific actions or decisions. Relevant studies tend to follow a process of analysis, a recipe, that starts with identifying the "real" questions and knowing what the final slides have got to look like before one starts looking for data or generating new data. Finally, relevant studies tend to be inclusive, collaborative activities. Collaboration helps get better expertise into the study; helps ensure that the study is comprehensive; and it helps prepare the stakeholders to support implementation of any decision resulting from the study. Lastly, analysts who produce relevant studies have avoided or broken out of the "model centric" mentality. They have practiced the analytic art. Remember, it isn't because we have the world's greatest models (which we do); "They keep us analysts around, because they like the way we think!". That last quote came from Dave Robinson, too. And you know what? He was right. ✪

The theme for the Education Colloquium this year is ...

"Sharpening the Saw -- Maintaining OR Professional Readiness & Relevance."

It will be held
21-22 April 1998
at the ANSER offices
located in Crystal City Virginia.

If you would like more information on this event please call COL Kenneth Konwin at 703-998-0660.

PHALANX, the Bulletin of Military Operations Research
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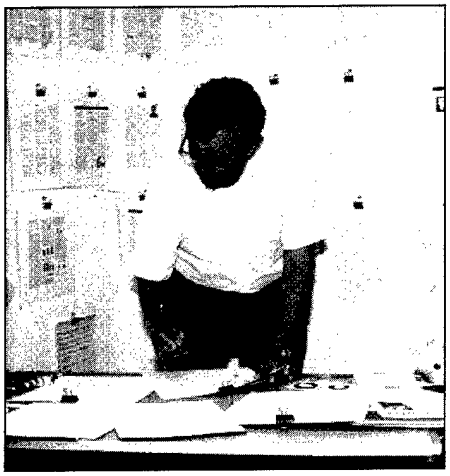
THE LAST WORD

Farewell to Jack Walker

Dick Wiles

When I came to MORS almost fourteen years ago, **Jack Walker** was one of the first MORSians (his term) I met. Jack was the Editor of *PHALANX*. I was the new Executive Director. Jack showed me how to put the *PHALANX* together, literally. Jack was not only the Editor but also the Composer. The PC and MAC were just coming on the scene. Composition was a mechanical, not electronic process. **Natalie** typed the text into columns which Jack pasted (actually waxed) to pages which went to the printer.

After a couple of issues, Jack submitted his first resignation as editor. One of my better decisions that year was to reject his resignation. The following year Jack submitted his resignation to newly elected President **Wayne Hughes.** Wayne prudently rejected the resignation (see "A Tribute to Jack from Wayne Hughes," pg 16). It became clear to me that this resignation



business was going to be an annual affair. I made it my business when orienting newly elected presidents to tell them to expect a resignation from Jack but to be sure to reject it.

Later, when Jack and **Tony** started wintering in Florida, it became clear that he did really want to retire. He was told that he could retire as soon as we found a replacement. He agreed to serve on the search committee that, about a year later, found his successor, **Dee Ritchie.**

Jack was editor for over twelve years (the longest tenure of all the editors). His first issue in August 1979 (Vol 12 No 3) was just twelve pages. His last in December 1991 (Vol 24 No 4) was thirty-six pages. When he retired (as Editor), MORS presented him a MORS chair, two bound volumes of his *PHALANXs* and made him Editor Emeritus. But Jack did not retire fully. He continued as a Department Editor and when MORS found itself "between editors" Jack pitched in as Acting Editor.

While Dee Ritchie and **Julian Palmore** have both put their own unique marks on *PHALANX,* it was Jack Walker who made it what it is. Jack will be missed. ✪