PROCEEDINGS OF JOINT AGENCY MEETING ON COMBAT SIMULATION ISSUES (JAMCSI), 30 NOV-1 DEC 88

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BETHESDA, MARYLAND

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PROCEEDINGS OF
JOINT AGENCY MEETING ON COMBAT SIMULATION ISSUES (JAMCSI)*

30 November - 1 December 1988

William W. Banks
Thomas E. Berghage
Dennis L. Kelleher
James A. Hodgdon
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Livermore, California

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Meeting reported Wednesday, November 10, 1988. William Banks, Program Manager, Systems and Human Performance, Lawrence Livermore National Laboratory, Building 1677, Room 2012, (415) 423-7181.

JOINT AGENCY MEETING ON COMBAT SIMULATION ISSUES

WELCOME

CAPT ROBERT D. CHANEY, MC USN

COMMANDING OFFICER
NAVAL HEALTH RESEARCH CENTER
SAN DIEGO, CA

NAVAL HEALTH RESEARCH CENTER
LAWRENCE LIVERMORE NATIONAL LABORATORY

JOINT AGENCY MEETING ON COMBAT SIMULATION ISSUES

NAVAL HEALTH RESEARCH CENTER MISSION STATEMENT:

TO SUPPORT FLEET OPERATIONAL READINESS THROUGH RESEARCH, DEVELOPMENT, TEST, AND EVALUATION ON THE BIOMEDICAL AND PSYCHOLOGICAL ASPECTS OF NAVY AND MARINE CORPS PERSONNEL HEALTH AND PERFORMANCE, AND TO PERFORM SUCH OTHER FUNCTIONS OR TASKS AS MAY BE DIRECTED BY HIGHER AUTHORITY.

NHRC INSTRUCTION 5450.1G
22 MARCH 88

NAVAL HEALTH RESEARCH CENTER
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WELCOME ABOARD

CAPTAIN ROBERT D. CHANEY, MC, USN

CAPTAIN CHANEY: First, let me introduce myself. I am Captain Robert Chaney. I am Commanding Officer of the Naval Health Research Center, San Diego. On behalf of the Naval Medical Research and Development Command and the Naval Health Research Center of San Diego, it is my distinct privilege to welcome all of you to what I am sure will be a very creative and productive meeting on combat simulation issues.

This meeting today is a component of a Naval Health Research Center contract with the Lawrence Livermore National Laboratory. It is designed to assist the Naval Medical Research and Development Command's Human Performance Modeling Working Group (headed up by LCDR Ron Chrisman), in the identification of promising areas of research on human performance issues related to combat simulation modeling. Better say that again. Human performance issues related to combat simulation modeling. That's what we are all about.

There will not be time for me to introduce everybody personally, but I sincerely hope that you will all get a chance to know one another so that everyone can take advantage of the enormous bank of expertise that we have represented here today.

As I said, I can't introduce everybody, but I would like to acknowledge one very distinguished guest--that is Dr. Earl Alluisi. Dr. Alluisi is the Assistant for Training and Personnel Technology for the Director of Environmental Life Sciences Division, under the auspices of Deputy for Research and Advanced Technology of the Undersecretary of Defense for Acquisition. Dr. Alluisi, we appreciate you taking time from an obviously very busy schedule to be with us today and share the expertise which you bring.

(Response from Dr. Alluisi: Thank you, sir. Pleased to be here.)

CAPT CHANEY: I wish to acknowledge the contributions of the representatives from our fellow Navy labs who you will hear more from later on. In addition, we want to recognize that the success of this meeting will be largely due to the contributions not only of those from our sister services, but also from the various corporations represented here.

I especially want to wish a hearty welcome to our potential customers. The ultimate success of this meeting is further assured by the participation and guidance of these operational and end users. We must be ever mindful of the fact that any development of more accurate estimates of combat performance must be usable within the context of operational planning. So I urge all the researchers present to capitalize and exploit, if you will, the collective expertise of these operational end users.

Now to the area of simulation of combat performance and its impact on the mission of the Naval Health Research Center.

"MISSION. To support fleet operational readiness through research, development, test and evaluation on the biomedical and psychological aspects of Navy and Marine Corps personnel health and performance, and to perform such other functions or tasks as may be directed by higher authority."

We take this mission statement very seriously. We have one job and that is to help the Sailor or Marine do his job better, safer and more productively. This is a fantastic challenge, it is an enormous opportunity, and we try very hard to live up to what is stated on that mission statement. There are portions of the effort and thrust that we at Naval Health Research Center are working on, in cooperation with other labs and the Naval Medical R&D Command.

Physical readiness standards. NHRC has for several years been the lead lab within R&D Command for the development and validation of physical readiness standards for the Navy. We are continually updating these standards, and this is an ongoing process we are called upon to revisit over and over again.

We also continue to do follow-on research in areas of performance enhancement through health promotion. Is this not in fact a good place to look at performance modeling?

Military task analysis. Along with the establishment of physical performance standards, Naval Health Research Center has been actively involved in operational task analysis. NHRC recently provided a team of researchers to go aboard ships of the line to observe and analyze the actual physical and mental requirements of each sailor in each job. This information was then analyzed and returned to the line Navy to be used in not only the selection of personnel for various jobs, but the training required to help these individuals to do their job more effectively.

Disease and Non-battle Injury (DNBI). This is a very important area of research. NHRC has taken an active lead role in the development of Navy/Marine Corps specific predictive models of disease and non-battle injury, the one question mark in any combat scenario. This is intended to: 1) lead to more accurate estimates of casualty and injury mechanism, 2) more accurate estimates of infectious disease rates, 3) the potential for more accurate force degradation estimates, and 4) the aiding of Navy and Marine Corps medical planners for more accurate estimates of the quantity of supplies, equipment and medical personnel necessary to meet real world contingencies.

Physiological and psychological determinates of combat performance. The purpose of this area of research is to analyze mechanisms of performance degradation with the aim of providing the means of enhancing performance. Not only do we find out what the problem is, we hopefully will be able to submit some ideas of how to fix some of these problems.

Areas of particular emphasis have been sleep deprivation and the adverse psychological reactions to stressful environments. A team of NHRC research physiologists and psychologists recently returned from their second data gathering deployment aboard surface ships in the hot, humid and extremely stressful Arabian Gulf. Our question was: what is the combined effect of heat, stress, sleep deprivation, and fatigue, in an obviously hostile, threatening environment? Think about the last time researchers went aboard combat ships of the line in combat or near combat to see the effect on the individuals doing their job. How can we incorporate this into a performance modeling effort?

Measurement of combat performance. The Naval Medical R&D Command has embarked on an aggressive research program relating laboratory based measures of physical and mental performance with field measurement of combat task performance.

While I was in the Arabian Gulf, I had a chance to talk to several of the senior members of the line community, one of which was an individual who was involved in the investigation of the Stark. As soon as he found out where I was from, he said, "We got to talk." He said the one common thread that went through the investigation of the persons who fought the fires aboard the Stark and ultimately saved the ship, was that the most physically fit performed the best in that stressful situation. Obviously this is an area that NHRC and all of the Medical Naval R&D Command have approached with great vigor.

NHRC's efforts have been focused on: 1) performance during sustained cold weather shipboard operations, and 2) Marine Corps operation in the arctic environment. This winter we will go with one battalion landing team of Marines from Camp Lejeune to the Marine Corps Mountain Warfare Training Center in Pickle Meadows, California, then to Wisconsin, and finally on to Norway. We will troop right along with these folks to find out what their problems are, what stresses they experience, what shortcomings we can help them with, and hopefully make their job easier. One more opportunity to work on a performance modeling effort.

We are also involved with the U. S. Navy SEALS working in special warfare operations in cold water. I am talking about Adak and Norway, and other inviting places of that type. How does this individual do his job, and how can we help him? How will the overall effects of sleep deprivation and fatigue affect performance during sustained combat operations in a cold environment? How do you incorporate that in your combat simulation models?

I would like to quit at this point because there are a great many people here who have far more specific presentations for you than what I am giving you at this point. I think it is obvious that the Naval Health Research Center and the Naval Medical R&D Command want very much to see what can be done to utilize this performance modeling effort. We appreciate all of your interest and your presence here today.

I would like to give special recognition to Bill Banks and Dennis Kelleher and all the rest of the people who helped put this together. Dennis and Bill Banks obviously have done a super job, and I appreciate what they have done to make this thing come about.

Once again I welcome you all here today. I hope we have a very productive meeting. Please talk to one another and make this a good information exchange.

MR. BANKS: Thank you, Captain Chaney. I would like to first of all welcome all of you to Lawrence Livermore National Laboratory. I would like you all to know that we are very honored to be able to work closely with the Navy in trying to forge this new thrust area of research.

I would like to introduce Captain Tom Jones from the United States Navy who will discuss the overview of Navy modeling needs--current and future.

CAPTAIN T. JONES, MSC, USN, NMRDC

CAPTAIN JONES: Good morning, ladies and gentlemen. My name is Tom Jones, I am currently the Research Area Manager for Aviation Medicine and Human Performance at the Naval Medical Research and Development Command (NMRDC), Bethesda, Maryland. I would like to express my sincere appreciation to the organizers of this conference on behalf of NMRDC for the invitation to talk to you this morning. Captain Melaragno, the Research Director at NMRDC, asked me to extend to you his regrets for not being able to attend this morning, because he is vitally interested in the area of cognitive psychology in general as well as in simulation and performance, which is the subject of today's and tomorrow's discussions.

During the trip yesterday, I attempted to develop notions as to how and what remarks may be appropriate for today. I decided to constrain my remarks to basically the job that I currently hold at NMRDC, i.e., these parameters that I manage as part of the human performance program.

Captain Chaney mentioned several that are currently ongoing at his laboratory. Other similar programs are being conducted at the Naval Aerospace Medical Research Laboratory (NAMRL) at Pensacola, and the Naval Medical Research Institute (NMRI) in Bethesda, Maryland.

It would be extremely pretentious on my part to assume that I could articulate effectively Navy modeling needs. It also would be presumptuous on my part to assume that I would be able to tell such an esteemed group of technical experts in the area of modeling anything technical that they don't already know. I therefore took the liberty to restrict my remarks to issues in modeling and human performance data bases. That seemed to me to be more appropriate in terms of the program that will follow.

As part of our ongoing research program we have incorporated the MicroSAINT model into the research efforts at the NMRI. It is also being considered as a modeling tool for work ongoing at the Naval Aerospace Medical Research Laboratory, Pensacola, and I think it is also under consideration at NHRC. This MicroSAINT methodology will primarily be used to exercise an evolving data base of psychophysiological data for the prediction of successful performance in sustained operations in both air, sea and special warfare environments.

In the context of scarce and reduced resources, and a continuing need for high quality R&D, I think there is adequate justification for the pooling of technical assets such as we see here today. The issues that we will address in the next couple of days hopefully will provide fundamental information that will assist me in managing my program more effectively, and help me utilize my scarce resources in a manner that will get the greatest productivity for the smallest amount of dollars. I would like to state explicitly that I fully support technical actions that are currently being taken to explore this technology thrust area, but I have reservations about the success that we might find in this particular technology area.

My introduction to the area of modeling started about 20 years ago at Naval Air Development Center in Warminster, Pennsylvania, when I was introduced to the HOS-1 system, and the concepts developed for HOS (Human Operator Simulator) by Dr. Robert Wherry Jr.

The purpose for bringing that up is I wanted to make two points. Number one, one of the problems that was confronted in this early work was that the computer hardware and the software and architecture were in their infancy, and the implementation of the conceptualization of HOS was made impossible. Secondly, the human performance data base required to drive the HOS system was not mature enough. I think that both of these problems were the fundamental reasons for the slowness in the HOS system evolving. I think HOS is now in its fourth iteration, and it's under the auspices of the Army Research Institute. The primary problems related to the computer and software aspect of the program I think have been resolved. But I am still suspicious of the data bases that are necessary to drive the program. The challenge, therefore, is to effectively integrate modeling tools, which are highly sophisticated, with the human performance data bases that are evolving.

The purpose of my participation is to rearticulate or reexpress some of the basic issues or concerns for successful incorporation or integration and use of human performance data into evolving models.

I would like to address four basic issues in the form of questions that I think it's necessary for us to keep in mind. I'll discuss each one of these separately.

The first question is, what is the goal of the model? Second, how good is the model? Third, what is the data base for the model? And fourth, what is the process that will result in the Fleet using the product?

Now, let's return to each one of these questions separately. I won't go into these things in depth, but just give you a flavor of each of the topics and the concern that I think that we need to bear in mind as we press forward on this program.

First, what is the goal of the modeling effort? What I would like to stress is the implication that somebody has to express what they want to use the model for, which brings up the question of the user in the fleet that Captain Chaney mentioned in his discussion earlier. I think that one of the fundamental difficulties that we have in effectively introducing such technology areas into the fleet is that we hold off too long in our efforts to actively involve Fleet participants in the design process. If the Fleet has a particular requirement that they need new technology to address, then it behooves us to clearly understand the nature of that requirement, so that we can tailor the evolving technology to meet the requirement.

Let's take an example of a flight commander who has a need for answering a question such as: what kind and what amount of nonpharmacological enhancements will he need in order to sustain his troops to effectively perform a particular on-site function? By knowing fundamentally what his question is, and by knowing the other related questions that should be asked, we are in a much better position to know how to go about the process of designing the technology. The bottom line issue is that we should not forget that the user is an asset to us in the evolving development of new technology. If we are here to do things for the fleet, than perhaps we should be talking to the fleet at an early stage of technology development.

The second issue is: how good is the model? There are four criteria that I want to bring up related to this particular question. Most of these things you have heard before, but I think it's necessary that we reiterate them, because the fundamental aspects of research are oftentimes neglected. If they are neglected, it leads to difficulties as we move through the process of trying to bring these technologies to the point that they can be effectively utilized.

The first criteria is trust. If a user of a modeling system asks a question, and an answer is provided or a response provided by the system, and that user has no understanding of the algorithms and how the algorithms are used to evolve or produce that answer, it's distasteful to them. This particular criteria has evolved out of some work that was done at NADC on Expert Systems. Trust is a dimension I think that is overlooked in terms of the goodness of the model.

The second criteria is acceptability. A critical issue that is very important from a user standpoint in terms of accepting a model is whether or not the user is better off by using the technology as compared to the previous system that he is replacing. Does it save time? Is it accurate? Both the trust and the acceptability dimensions are direct functions of effective interaction with the user community.

The third criteria under goodness of the model is assumptions. It is imperative that we clearly define and make explicit what the advantages and disadvantages of the model are, and more importantly, understand the data bases that are driving the model. A simple example that you are probably all aware of relates to the general use of linear regression for treating data within the context of a model. However, the human performance data bases that are available clearly indicate that the data are not necessarily linear.

For instance, the inverted U shape curve clearly shows that as stress increases initially there is an increase in performance, it flattens out, and then as stress continues to increase, there is a falling off. To use a linear model to predict that sort of performance seems inappropriate. This is an issue that we should be sensitive to.

Another example of the complexity of the human performance data bases is found in simple psychomotor tasks. Stress facilitates performance and results in faster reaction times. For complex tasks better performance is found in the absence of stress. So the assumptions that we make relative to the use of the model, as well as the assumptions that we make relative to the data bases that are feeding into the model we use for the predictions, are issues that we as technologists should always keep in mind.

The last criteria under model goodness is the concept of validity. Most of you know what I am talking about. I am not going to go into that to any extent, other than to say that fundamentally what we are talking about when we use the word validity, it is how well the model does what it's supposed to do. It is the link with reality. It establishes the credibility of the instrument for the purpose that the instrument was designed for.

As most of you well know, this is an extremely complicated and difficult issue, particularly when you consider predictive validity (trying to predict operational performance), because of the tremendous variability that is found in operational environments. It's difficult to sort out and refine techniques that will clearly indicate what a particular model is doing, or effectively assess whether a model is doing what it's supposed to do.

The third major topic to be addressed is: **what data bases are used for the model?** There are several kinds of data that we can address, but I am going to focus explicitly on the empirical data bases, because most of the laboratories that are currently working in the advance program for Naval Medical Research and Development Command are doing empirical studies either using regression analyses to tie the independent and dependent variables together, or doing analytical studies to evaluate relationships between independent and dependent variable. Two issues that I want to bring up related to the data base question are: (1) fragmented studies, and (2) the issue of generalization.

What I mean by fragmented studies is that you can develop or design studies that are addressing questions in the same area. For instance, we are asking questions about the effect of physical fitness on G tolerance. One study may have one fitness regime and one criteria for the effects of G tolerances, e.g., contrast sensitivity, visual contrast sensitivity or peripheral vision.

If we try to assemble a family of studies that put together different independent variables against different dependent variables, e.g., peripheral vision, contrast sensitivity, there is a problem. It is extremely difficult to combine studies together in a composite data base in a way that will provide the data needed for the modeling effort. The bottom line related to the data base issue is that we have to strive to develop appropriate data bases with a clear view of model requirements and model analytic techniques.

The fourth major question is, what is the process that will lead to fleet use? The linkage has at least four fundamental components: (1) a requirement; (2) a user; (3) a technology base/development; and (4) a transition system. I bring this last one up because I think it is imperative that principal investigators be aware of and understand the components essential for getting their products, whatever they are, from point A or B to the Fleet.

The concept of requirements is really handled loosely in the context of R&D in my view. Basically, documentation is set forth and signed by somebody saying that research needs to be done for a particular platform, but it doesn't specify clearly what needs to be done and who is going to use it. I continue to come back to the user because I think it is key to effective use of the concept and the structure that we have set forth for our research requirements development.

If we have only a requirement and have not clearly identified the user and what he needs, what we may find ourselves in is a technology swirl where we go from 6.1 type funding to 6.2, to 6.3, back to 6.2, and back to 6.3. There is no way out of the box.

It's a complicated issue, but again an issue that the program managers as well as principal investigators need to keep clearly in mind, because they are mechanisms by which technology can transfer directly from 6.1 in some instances to 6.4, or 6.2 to 6.4, or it may transfer directly to industry. There are mechanisms. We need to maintain awareness of them.

So in summary, the four basic issues that I have tried to emphasize that I think are important for us all to keep in mind are: (1) what is the goal of the model, (2) how good is the model and the related criteria for that, (3) what are the data bases for the model, and (4) what is the process that will lead to successful fleet use. If product transition is the goal (and it should be), then the user should be involved.

For years, human factors professionals in the systems acquisition process indicated to people, when they came to them with a problem in an aircraft system that was identified during testing and evaluation, "If you had come to me during the design phase, you wouldn't have this problem now. Now I can't fix it, all I can do is document it."

Why should we not look at research and development the same way, i.e., bring the user in at the front end of the thing as we go through the process of iteration, and we'll have a product that's smoothed out and it is transitional. User involvement allows for trade-offs between the user input notion, the model fidelity and the data base issue. The health of those trade-offs will smooth the way for technology transfer and improve productivity and research.

Now, I haven't told you anything that you didn't already know. But what I have told you is that basics in research lead to quality research and I am interested in quality research. The transition system is complicated, but with hard work and determination it is approachable and can be utilized. Modeling technology integration with human performance data bases is really the key that we have to keep in mind as we approach this subject. Lastly, human performance modeling is an important technology thrust for the Naval Medical Research and Development Program.

I thank you very much for your time. I am looking forward to hearing the briefings to follow, and to participation in the discussions.

Thank you.

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JOINT AGENCY MEETING ON
COMBAT SIMULATION ISSUES

MEETING OBJECTIVES AND ORGANIZATION

LCDR DENNIS L. KELLEHER, MSC USN

NAVAL HEALTH RESEARCH CENTER
SAN DIEGO, CA

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JOINT AGENCY MEETING ON COMBAT SIMULATION ISSUES

MEETING OBJECTIVES

* ENHANCED AWARENESS WITHIN NMRDC OF HUMAN PERFORMANCE ISSUES RELATED TO COMBAT SIMULATION MODELING
* DEVELOP WORKING RELATIONSHIPS AMONG ORGANIZATIONS WORKING IN THIS AREA
* DEVELOP PROPOSED TECHNICAL REQUIREMENTS FOR FURTHER RESEARCH IN THIS AREA

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THOMAS BERGHAGE, CDR MSC USN (Ret.): Thank you, Captain Jones. My name is Tom Berghage, and I'll be standing in for Bill Banks for a few moments.

Our next speaker has been in the forefront in the modeling effort in the Navy for several years. He has had first hand experience with the problems associated with incorporating human factors information into a simulation model. This experience has given him some valuable insights into the problem. Without any further ado, I would like to introduce to you LCDR Dennis Kelleher.

ADDRESS BY LCDR DENNIS KELLEHER, MSC, USN

LCDR KELLEHER: Thank you. I first got involved in this business back when I was at the Defense Nuclear Agency, where we worked on a program that was looking at the issues of how do you go about trying to deal with data bases that are incomplete. You have an identified requirement from an end user to come up with predictors of performance, and the available data bases are incomplete. You will hear some of that during the presentations today.

To clarify why you were invited here, it's easiest to go ahead and display the Statement of Work that we negotiated with Lawrence Livermore National Laboratory, so you can see the elements of what were requested of Livermore, and basically what we at NMRDC expect to get out of this meeting.

The two products that you received this morning are the first deliverables on the contract. The products are: (1) "Review and Analysis of the Literature in the Area of Human Performance Modeling," and (2) "An Inventory of Wargaming Models for Special Warfare: Candidate Applications for the Infusion of Human Performance Data."

The second contract requirement is to host this meeting to not only increase the awareness within NMRDC of combat performance and related issues, but maybe to get some continuing momentum back into the effort. As it turns out I think we got a flier (as most of you did) that the Military Operational Research Society (MORS) is going to follow-up with another meeting in February where, if you read our Statement of Work and their announcement, you would think they were the same thing.

JOINT AGENCY MEETING ON COMBAT SIMULATION ISSUES

NHRC RESEARCH EFFORTS

COMBAT PERFORMANCE ISSUES

** PHYSICAL READINESS STANDARDS

** MILITARY JOB TASK ANALYSIS

** DISEASE AND NON-BATTLE INJURY ANALYSIS

** PHYSIOLOGICAL AND PSYCHOLOGICAL ASPECTS OF COMBAT PERFORMANCE

** ENHANCEMENT OF COMBAT PERFORMANCE

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The last contract requirement for Livermore is to provide assistance, hopefully along with all of you, in refining the technical requirements for NMRDC's further efforts in combat simulation modeling and human performance modeling areas. It's been an area that certain components of the Navy have been actively involved in for many years, but we want to take a much broader view of how we can take our data bases and our expertise and export them to the Fleet and the Marine Corps.

There are some specific meeting objectives, the first being an enhanced awareness within NMRDC of human performance issues related to combat simulation modeling. We also want to meet everybody and develop the necessary working relationships that go on within the community of modelers. It's an area that most of us have not had much background in and we want to enhance and broaden our knowledge of computer modeling by building a professional network. The final objective is the technical requirements development. That is, to refine and report general sense, and to a certain extent a lot more specific sense on how we, at NHRC specifically (and NMRDC), can make the models work better. When I say the models I mean the models that could be under development, along with the models that already exist.

Today we are going to look at an overview, just a very basic overview of models that already exist, models that we selected for presentation at this meeting based on selected criterion. The first criterion basically is that these are models that have Navy utility. The types of models that will be presented today run the whole spectrum of existing concepts of combat simulation models within the Department of Defense.

For Combat modeling, you will hear a presentation on Janus, of a, combat simulation model. The reason you are going to see Janus is because some of the data from the Intermediate Dose Program (ITMED) has now been put on Janus, and you will see that human performance decrement issues might necessarily turn an engagement that used to be a win into a loss. So you will see that there is the real requirement to begin to import human performance degradation issues directly into combat simulation models.

The second model you will see a presentation on is the SEES model, which is also a Lawrence Livermore product. It's a small unit force on force engagement model, an infantry type engagement, that has the capability of being constructed for urban terrain, and/or plain old operational terrain. The operations can consist of units of as

JOINT AGENCY MEETING ON
COMBAT SIMULATION ISSUES

NHRC/LLNL STATEMENT OF WORK

* CONDUCT A LITERATURE REVIEW OF COMBAT SIMULATION MODELING WITH EMPHASIS ON THOSE MODELS WHICH ACCEPT HUMAN PERFORMANCE PARAMETERS OR FACTORS WHICH DEGRADE HUMAN PERFORMANCE AS INPUT VARIABLES

* CO-HOST THIS MEETING ON COMBAT PERFORMANCE MODELING

* ASSIST NMRDC/NHRC IN DEVELOPMENT OF TECHNICAL REQUIREMENTS FOR FURTHER RESEARCH RELATED TO COMBAT PERFORMANCE MODELING

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little as one man all the way up to a company size force, and can import directly human performance information.

The third model you will see presented is the TWSEAS model, which is the Marine Corps' command and control exercise model. It's routinely run at Camp Pendleton, Camp Lejeune, Quantico, and is now going to be run at Okinawa as well. This particular model is currently undergoing revision, and is being changed to import a module that will accept human performance decrement information.

There are also resource allocation models, if you will; that is, models that look at division level and Army level engagements to see how you would move forces about the battle field to take optimal advantage of a situation. These models also can directly import human performance information. The model that you will see presented is the AURA model from the Army's Ballistic Research Laboratory (ABRL).

We also have weapon effects models; the classical old models of, given a level of weapon effect, what do you expect to be the result both in terms of physical damage, and now also in terms of people damaged.

The modelers from David Taylor Research and Development Center (DTRDC) will present the SHIPDAM model, which traditionally was viewed as just a hardware damage model, but now more recently has been used in an attempt to predict shipboard casualty production.

As one looks at all of these models, the first approximation has always been casualty production, because casualty production is the ultimate performance or force degrader. However, it's also necessary to view factors other than total casualty that can degrade a combat force. Degraded combat performance can be caused by a number of factors. How does one decide what's going to be the characteristics of force degradation when you have less than total destruction of force capability? Weapons effect models unfortunately, until the recent introduction of the intermediate dose parameter, didn't really have a mechanism for looking at less than casualty produced performance steps.

Tomorrow morning we'll break up into working groups in which we will identify a couple of specific areas that we would like to look at. One of the four working groups will be on model input/data characteristics: Do we have enough data already? (could be a very real question). Do we need to continue to generate at-the-bench data, or do we not have a good enough handle on the data bases that already exist? Would we be better off by just marshalling the data bases that currently exist?

The second working group will be addressing the issue of what are the model output requirements. Output requirements to the end user mean a variety of things depending on whether you consider yourself an end user or not. Certainly the operational forces are an identified end user. I, however, identify myself as an end user and I am just a physiologist. The reason I identify myself as an end user is that models will help me do better research. If I can get a handle on which factor degrades performance, that should help me define a relevant experiment to look at performance enhancement. Models can also help the program manager prioritize his efforts, because he could look at those areas that would be the most promising for further experimentation. So the end user is not just a fleet operator. He is anybody who could usefully use the model to define requirements, to define research areas of interest, and to allocate necessary resources.

The third working group will deal with transfer functions. The model transfer functions are actually some of the problems that have traditionally been dealt with in human performance modeling, that is, how do you turn something like physical performance data into an estimate of combat performance? The transfer function for using raw physiological data or raw psychological data as a determinate of combat performance has been a real problem. These are the black box functions of how you go about extracting useful information from the data bases.

The last working group will be one which will address the issues of model validation; that is, what does it really mean to have a validated model? Beyond the obvious answer that if the end user says it's good enough, then it's good enough, well, that may not be the case. So we want to have a more precise definition of what is meant by model validation.

Now, whose model is it and are we building a new model? Maybe not. We are not starting with a preconceived notion that we are out to build a new model. As I have said, you are going to have presentations today on models that already exist, and are already being used by the operator to define requirements. It might be that the only requirement coming out of this meeting is to tell the Navy to do a better job of looking at the data so that you can give us better estimates of performance decrement so we can

JOINT AGENCY MEETING ON
COMBAT SIMULATION ISSUES

MEETING OVERVIEW

* COMBAT PERFORMANCE MODELING: WORKING GROUPS
    ** MODEL INPUT/DATA CHARACTERISTICS
    ** MODEL OUTPUT: END-USER REQUIREMENTS
    ** MODEL TRANSFER FUNCTIONS (BLACK BOX)
    ** MODEL VALIDATIONS REQUIREMENTS

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JOINT AGENCY MEETING ON COMBAT SIMULATION ISSUES

MEETING OVERVIEW

* COMBAT PERFORMANCE MODELING: AN OVERVIEW
  ** STRATEGIC/THEATER
  ** SMALL UNIT COMBAT OPERATIONS
  ** COMMAND AND CONTROL EXERCISES
  ** RESOURCE ALLOCATION MODELS
  ** WEAPONS EFFECTS MODELS

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use our models better. We are perfectly willing to accept that the Navy doesn't need to be told to go out and build a new human performance model, and that's why we are going to see the variety of models as they exist today. Keep in mind that we need to view the whole spectrum of performance degrading factors.

When we look at a model, we should look at a model as a true estimate of combat simulation. We should look at the full spectrum of the factors that will degrade performance in combat. They should go all the way from weapons effects down to adverse psychological reactions. That is a big task and it's not necessary that the whole pie be baked in the oven at the same time. It might be very possible that we could be talking about module production so that he could look at importing models of performance decrement into models as they now exist.

It used to be thought that these questions are too big. We can't do anything about them. Well, with modularity we have the option of breaking these questions down into smaller workable pieces. Something to think about in our working groups.

The factors shown in this figure are the ones in which the Navy/Marine Corps have traditionally been most interested.

My particular interest is the effects of cold. I will be deployed with the Marines this winter to find out why Marines perform less well in the cold than they do in heat.

You will see this figure tomorrow in the working groups, but I would like to present it today so that as you see the presentations today you can be developing thoughts within your own mind about what you are going to say tomorrow in the working groups. These are the questions that maybe won't be answered, but certainly are the types of questions that we should be thinking about in coming up with conceptual approaches to modeling efforts.

Are there identifiable limits to what we really can do in modeling? Should we go ahead and say yes, it would be nice to have a complete total concept of what a Marine Corps division is going to do if you put them in Norway with -23°. It would be nice to be able to tell the Marine Corps that that's simply going to be an impossible task. Where along that spectrum of knowledge should we limit our efforts, and are there identifiable limits with respect to input, output, model transfer functions, and validations? Model validation becomes a very difficult proposition when dealing with nuclear weapons effects. You do not go out and irradiate troops to find out whether your model is valid or not. So we had to come up with a convoluted way to validate that model. The same would hold true for a lot of models.

Are there constraints to progress in this area? We no longer think there are hardware-software constraints to modeling, whereas 20 years ago there were. Are there still data constraints? This is a very real question. Do we have enough data already? The nice thing about building models is they can identify those areas where you don't have enough data. So it allows you to prioritize your research efforts for subsequent work.

Is there commonality among organizations in how they use models? Is there commonality in how the Marine Corps conceives of using a model, how the Navy conceives of using a model, how the Air Force uses them, and how the Army uses them? Can we exploit that commonality? Are there operational and methodological considerations within that commonality that will allow us to share the information?

Are there identifiable essential elements as Captain Jones suggested? If there are, we should have those clearly identified. Hardware essential elements or software essential elements, or weapon system considerations all need to be taken into consideration.

Again, the four areas of interest are input, output, transfer functions and validation. Your guidance with regard to these four areas will help the R&D Command develop technical requirements for modeling. You can also help them develop a time and resource allocation plan. We should also be making a list of products that we feel can be developed for end users. The agenda I have just laid out is very aggressive and we may not be able to accomplish it all, but we will have taken the first step in our attempt to coordinate efforts.

For the rest of the day we want to go through a review of a selection of existing combat simulation models, not to show any prejudice whatsoever as to the consideration of these models, but to give a flavor of the full spectrum of combat simulation models from weapons effects through theater/strategic decision making models.

JOINT AGENCY MEETING ON
COMBAT SIMULATION ISSUES

PERFORMANCE DEGRADING FACTORS

* WEAPONS EFFECTS
    ** CONVENTIONAL
    ** NUCLEAR
    ** CHEMICAL
* ADVERSE OPERATING ENVIRONMENTS
    ** HEAT/COLD
    ** ALTITUDE
    ** DIVING
* OPERATIONAL DEMANDS
    ** SUSTAINED / CONTINUOUS OPERATIONS
    ** JET-LAG / SLEEP DEPRIVATION
* DISEASE AND NON-BATTLE INJURY
* ADVERSE PSYCHOLOGICAL REACTIONS

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JOINT AGENCY MEETING ON
COMBAT SIMULATION ISSUES

CRITICAL QUESTIONS

* ARE THERE IDENTIFIABLE LIMITS FOR THIS AREA
* ARE THERE CONSTRAINTS TO PROGRESS IN THIS AREA
    ** HARDWARE ?
    ** SOFTWARE ?
    ** ' DATA ' ?
* IS THERE COMMONALITY AMONG ORGANIZATIONS
    ** OPERATIONAL ?
    ** METHODOLOGICAL ?
* ARE THERE IDENTIFIABLE ESSENTIAL ELEMENTS
* WHAT SHOULD BE REASONABLE EXPECTATIONS
    ** TIME ?
    ** RESOURCES ?
    ** PRODUCTS ?

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The Janus Combat Simulation System

December 1988

Presented by:
Ralph M. Toms
Janus Project Manager

Janus Is A Two Sided Interactive Land Combat Simulation System That Supports:

- The evaluation of advanced weapons technologies in a high resolution combat simulation environment.
- The evaluation of tactics, countermeasures and alternative force structures.
- The stimulation of creative new ideas with immediate feedback for testing hypotheses.
- The provision of a commander training environment ranging from the level of platoon to division.

CDR BERGHAGE: The first model we are going to hear about this morning is the granddaddy of them all, the Janus model which was developed here at Lawrence Livermore. And to tell us about that model will be Dr. Toms and George Anno.

ADDRESS BY DR. RALPH M. TOMS

DR. TOMS: Good morning. There are some misconceptions we need to take care of. One is that Janus is not an acronym. Janus was a Roman god who had two views of the world, one red and one blue. So parameters notwithstanding, it's a good idea if you don't capitalize Janus. Janus though, is a combat simulation system, not a model. That's important. I am going to emphasize that overall.

Captain Jones talked about four items that made a model good. One of them was openness that you publish within the model. We are a research center; you can get all the documentation of Janus. The algorithms, documents, and user manual are all public property.

During this presentation I will show you a date log list of the users including the Navy. We document our limitations as well as our strengths. I have even got a chart in the presentation which talks about our limitations, which are mostly in the arena of human factors which we don't model. We currently have an effort going on right now to validate Janus.

Also I want to say one other thing before I go on with this presentation. In the up-to-date catalog of models that you received, the description of Janus is out-of-date. Janus was built by the Department of Energy, did not involve any Army funds, and is not controlled by the Army. I belong to the Conflict Simulation Laboratory here at Livermore, that is completely funded by the Department of Energy. Bob Terhune, who is the next speaker, also belongs to the same organization.

There is some confusion because Army people come up to me and say, "Give me my model." But they don't own the model. So if you want to find out about Janus, get a hold of the Janus project manager. Janus is an analysis tool, a research tool, and a training tool. There is a lot of interest in training right now, which I will be talking about.

We ran combat simulations from platoon, or really from the individual soldier to the division level. We don't simulate theater operations. We have a model under development in our laboratory called CONMOD, which will be a corps and echelon above corps model that simulates higher level activity. We are not talking about this product today because it's in an early development stage, but I am sure next year or the next time you have a conference like this, we will have that project manager present.

In Janus one way we try to model a human being is put him in the loop. Players are involved in tactics and doctrine. We don't automate the tactics in Janus. We, however, provided a non-interactive mode operation, because there are all these statisticians around that say, I need to run 17 independent simulations, that's where the median of the curve is. So we also provide that as an alternate mode.

The model is high resolution and balanced. We don't model the forces on the bullet, but we do simulate attrition at the item system level. People shoot at people, tanks shoot at tanks, people shoot at tanks, and so on. We don't aggregate that information through something like Manchester equations. We actually stochastically play the game. Part of the reason we do that is because the lab traditionally beats everything to death with computers, and models the heck out of the physics. That's what we are trying to do.

In at least the interactive mode we force the simulation to run at real time. Normally it runs faster than real time, but we put a governor in there and force the people to make decisions the same way they would in the real world, albeit not always under the conditions of the real world, but I guess we could get them out, get them cold, do that if you wanted to.

We do model stochastic attrition. We do model three dimensional terrain, weapons system characteristics to engineering detail, and weapons effects to engineering detail. We actually use LAMSA based test data, PK/PH data. This is very important; part of the philosophy of the lab is to be open about our product. Our simulator is data base driven. To all the extent possible, all of our data is under the control of the user. If you want to play some alternative data base, you don't have to recompile the code. It's not true of all models, some of you may have noticed. If you want to simulate snow, the programmer says, "I'll do that for a small fee, because I have got to recompile the parameter, because I put the coefficient in a data statement inside the code." Of course,

Janus Objectives

- In the interactive mode, feature two sided competitive play to keep player in the loop for decisions of doctrine and tactics.
- Provide a non-interactive mode for Monte Carlo simulation.
- Provide a balanced high resolution model.
- Simulate events in real time.
- Model stochastic attrition.
- Model physical factors.
  - Environment and terrain
  - System characteristics
  - Weapons effects
- To provide a data base driven simulation so that users can change model parameters without needing to recompile the software.
- Model and display primary and secondary nuclear weapons effects.

Janus Is A System Composed Of:

- A host computer and attached interactive player terminals.
  - Host can be any of DEC VAX family, 8800 to VAXStation 2000.
  - Up to eight interactive color graphics Tektronix 4225 terminals.
- Software that supports combat simulation.
- People (players and analysts).
  - Up to 16 players per simulation (two graph tablets per station).
- Added systems (radios, telephones, other communications devices, other simulators,...).

one of our main reasons for Livermore's involvement is to model nuclear weapons. That's why we are in this business.

I said that Janus is a system; it's composed of computers, host computers, a whole family of them, and color graphics work stations or terminals. The terminals are Tektronics 4225 because they are luminous, high luminescent displays, and have four megabytes of local memory, but the big attribute is they are cheap. Much cheaper than they used to be. They are 15K apiece. You can put together a low end Janus work system on a Tektronics work station about the size of a PC, and have it in your office these days. Five years ago it was a half a million to get a Janus system like that. That's the direction hardware is going, and it's going to get a lot better. You need the software. I don't mean to diminish the software. The importance is not 150,000 lines of code in Janus. You need people, players, and analysts if you are running; particularly in the interactive mode you can have 16 players per simulation, two per terminal. You can add systems; radios, the output of other simulators, you can put together all kinds of games using Janus as a driver for the attrition aspects of combat. It has been done. I have a whole list of studies that have been completed.

You may read in the literature about something called Janus T. In 1983, General Start saw Janus here, decided that the Army should have it, the lab cut a Memorandum of Agreement with the Army, sent Janus in its state in 1983 to the Army, and they call that Janus T. It still exists. The models are different now. They have drawn apart, both in terms of algorithms and functionality, but particularly in terms of hardware. So I want to use this chart to illustrate the differences in hardware.

The Army has seen fit to retain the essential architecture we had in 1983, when we had a host computer which did all the graphics and applications processing inside the host computer, then sent data out over big fat parallel lines to graphics display terminals. We abandoned that in 1983 because we didn't want to do all that graphics computing on the host and tie up the machine. You couldn't get very far away from the computer with your graphics display generator because of this big baud rate requirement. Every time you have a terminal you have got to do more graphics computing, which means you slow the system down by quite a large factor.

The graphics code in the 1983 system was mixed in with the applications code, and we knew that modern 32 bit microprocessor base products were coming out and we wanted to separate the graphics out so we could exploit the new capability. We went to

Janus Can Operate In Two Modes

<u>Interactive Mode</u>

- Real time play
- Players provide tactics and doctrine
  - Innovative
  - Complex interactions
  - Surprise
  - Ideas/concepts/perceptions
  - Competitive
- Disadvantages
  - Difficulty with repeatability
  - Requires trained player cadre/time
  - Cause/affect obscured

<u>Batch Mode</u>

- Graphics insights available
- Repeatable for statistical analysis
- Allows single parameter variation
- Allows quantification of rules of thumb
- Uses same models and algorithms as interactive mode

The Janus Simulation System is Installed at Thirteen Locations as of November 1988

EXISTING SITES

LLNL, Livermore, CA.
US Army War College, Carlisle, PA.
Warrior Preparation Center, Einsiedler Hof Air Station, FRG.
Atomic Weapons Establishment, Aldermaston,UK.
USA TRADOC Analysis Command, Monterey, CA.
USAF Combat Operations and Exercise Division, Washington, DC.
USAF Wargaming Center, Maxwell AFB, AL.
Sandia National Laboratory, Albuquerque, NM.
US Southern Command, Panama City, Panama.
Canadian National Defence Headquarters, Ottawa, Ontario.
Institute for Defense Analysis, Alexandria, VA.
USA Intelligence Center and School, Ft. Huachuca, AZ.
USA Combined Arms Center, Ft. Leavenworth, KA.

PENDING INSTALLATIONS

I-Corps, Ft. Lewis, WA.
US Marine Corps, Quantico, VA.
Intelligence Threat Analysis Center, Wash. D. C.

kind of a star design in which we have a host computer and it just does the applications processing, and we have gone to a little fancier (and as it turns out much cheaper) terminals, in which all the graphics are done locally.

That means you don't need a high baud rate line. That means (among other things) that you off-load the graphics processing from your host and end up with a distributed system. This is very important, because the communication lines can now be telephone lines. We have operated Janus with the reds in McLean, Virginia, and the blues here in Livermore. You could theoretically have a computer in Livermore, and the eight stations anywhere else you wanted, running on telephone lines. You can't tell the computer is not in the next room. You can add terminals and it doesn't really slow you down, unless the guy on the terminal starts doing weird things. We have decoupled the graphics from the physics in order to position ourselves for even more advanced changes that are coming out.

The Janus screen looks something like an arcade game, only a little fancier, maybe with a menu. There are blue screens and red screens, and you can highlight the information from the different players. You can do things during the game (or in this case before the game starts) to find out what you can see from independent positions. A cursor gives you a line of sight fan.

One of the neatest things we have done with Janus in recent months (I guess in the last year) is added a capability called "command control graphics." Command control graphics is an ability to draw on a screen in an overlay plane any graphic symbology you want free hand, or using precanned symbology. So you don't need a grease pencil, a transparency, and a map any more to do your analysis, you can do it right on the screen. That's nice. What's even nicer is that I can store that as a message and send it to any other terminal in the system. So if you had one of these in San Diego and you wanted to send information to some place in Maryland, you could.

This has tremendous utility in doing training for a commander. You can give a commander a terminal, no acquisition data, just a map and his usual assets, such as radios or pieces of paper, or however he gets information. He creates a battle plan based on his information, sends it to his subordinates who are operational commanders, and they execute his plan. Operational commanders are getting acquisition data and they are fighting the war. They send back information, and might say "Hey, boss, you are all screwed up. That's not a division, that's a whole army." He gets the information and adjusts his plan. You can see how this iteration might work as a training process.

I already mentioned that Janus can operate in two modes. In the interactive mode, of course, we can force real time play. It features innovation, very complex interactions, and surprise. There is some difficulty with repeatability, which is now going away because we are finding out that it really isn't a difficulty. When you have a large game, you stress people and they are trained, they always do the same thing, more or less, as it turns out.

These are the current installations of Janus. This is not Janus T. Janus T. is also installed (I think) in eight places now. Of course, we have it here. It's at the Army War College, Warrior Preparation Center in Germany and the Atomic Weapons Establishment in England. All this work is being done under a joint working agreement among the labs. TRADOC in Monterey California, is an Army facility, and in the very near future will be connected with the Navy Postgraduate School. They serve as a Beta test sight for us. Both the Air Force and the Sandia National Laboratory have systems. The last five installations on the list were all done this year. IDA, the Institute for Defense Analysis, bought an eight terminal system. We also just installed an eight terminal system at Fort Leavenworth under what's called the Thurmon Initiative. When General Thurmon saw the system he got pretty excited about it, and as a result of that we gave the Army a system.

There have been numerous studies with Janus, and I'll point out a few here because the Defense Nuclear Agency (DNA) is here. We have done several studies, and are conducting one right now for implementing an upgraded intermediate dose model. Art Deverol gave a paper during the summer showing that radiation dose effects and light effects really make a difference on the outcome of an engagement. We are continuing to work on this model.

We have a users conference here each year. We just had one about three weeks ago, there were 60 people attending. Several papers were given by personnel at the Navy Postgraduate School on various subjects related to Janus. They used the Army system located in Monterey. They said the Navy didn't have anything like this, and they were quite excited about this utilization of Janus.

Janus Has Been Used For Numerous Studies. Selected Examples Are:

- US Air Force
  GLCM Pre-Launch Survivability
- US Marine Corps
  Air Defense Systems Evaluation
- US Army
  Nuclear Weapon Mix Studies AFAP I&II
  Beam Weapon Operational Concept
  Force Structure of Corps Cavalry
  Force Structure of Division Cavalry
  Battlefield Management System
- Defense Nuclear Agency
  Advanced Conventional Weapons/Tactical
  Nuclear Weapons Comparisons
  Intermediate Dose Program (ongoing)
- Naval Postgraduate School & TRAC -Mnty
  National Training Center Data Evaluation
  Tomahawk Land Attack Simulation
  Land Attack Missiles in Support of Army
  Airland Battle
- Theater Applications Group (D-Division)
  Mission Area Analysis Nuclear Excursion Study
  MLRS/TGW(in progress)
- External Janus User Sites
  Numerous Studies
- Janus(T) Sites (Army Version of Janus)
  Numerous Combat Developments Studies

Janus As A Representation Of Real Combat

- Janus is the most complete high resolution interactive combat simulation known to exist.
- However, combat simulations do not adequately model all factors that influence combat.
- In the case of Janus these factors include:
  - those which are not well defined and therefore cannot be readily measured or directly modeled (e.g. the fog of war, courage,...).
  - those for which the Army has approved models but the models are only validated for a subset of real world conditions (e. g. acquisition).
  - those which can be modeled but have not been due to resource constraints (e. g. direct fire suppression, fratricide, superposition avoidance, dead targets, reliability,...)
- Many of the unmodeled factors can be indirectly modeled.

There are some human performance models in Janus, where we change performance rates for clearing obstacles, getting on and off vehicles, transferring fuel or ammunition and that sort of thing. We have a forward observer model for artillery in which people's ability to estimate speed and things like that are included.

One of the things we don't want to do as modelers is implicitly believe what's in a model. Models are used as guidelines. This comes back to Captain Jones' comment about the importance of knowing what's in the model. If you interpret the results of the model and you don't know what's in there, that's your problem, not the model's problem. We think Janus is a good high resolution model. We don't model everything. Some of the things we don't model are human factors. We don't model courage, we could. You give me a courage model and we'll model it.

Bob Terhune is going to talk about some upgrades he has done in SEES for acquisition of people by people. Janus tends to be oriented towards acquisition of systems, tanks and airplanes, and that sort of thing.

There are a number of things we just haven't modeled because we either don't have the time, the resources, or the money. We have a long list of things that need to be done. In spite of all the noise we make on Janus, we have operated the program with one operator analyst and one project manager. That's it. I have been allowed to hire some more people here recently and we are expanding. We are going to be able to address some of these issues soon.

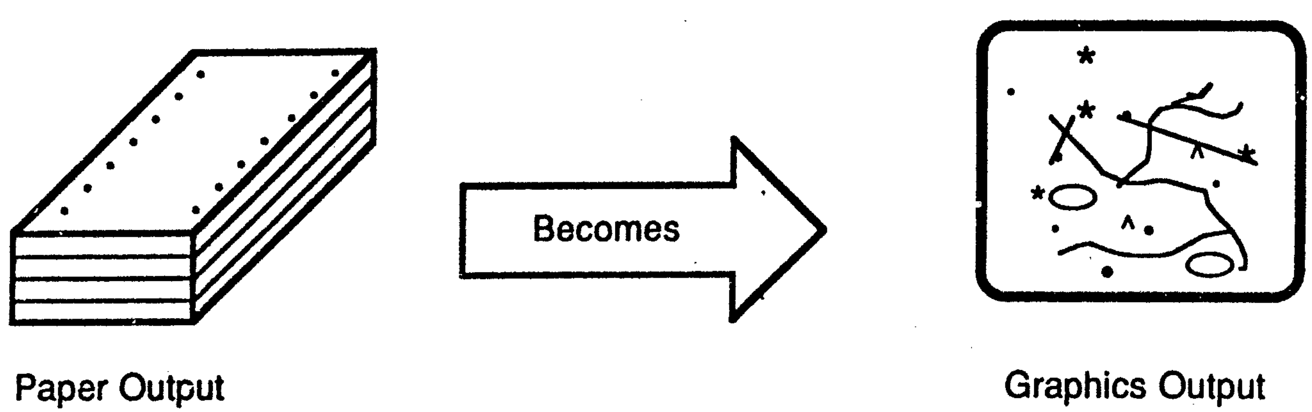
I am going to talk a little bit about a new product called the "analyst work station," which I think should be of interest to this community. Why am I talking about this? Well, if you have an interactive war game or a war or field exercise, it's not easy to tell what happened after the fact. In wars it's really tough because you can't get any volunteers to stand out there and report things, as in the days of the scribes when they used to do that. There is a lot of free play, and you can't see everything. There are tactics. In the case of Janus, the controller is trying to monitor a game with the terminals maybe not in the same county. That's hard to do. So we went out and built something called an "analyst work station," and we set out as requirements that we minimize development costs by using everything we had. Hardware had to be the same as Janus uses. We didn't want the person using it to have to be a data base management expert. I think it's very important here that the design be as generic as possible, so we

THE

ANALYST WORKSTATION

AWS Can Represent Simulated Combat Data Graphically With a Map Background

- Results are represented graphically in the context of Janus symbology and terrain map background.
- AWS can be thought of as an interactive color graphics assisted relational data base system.



could go to Terry Kolpcic and punch his results up on this system or any other model, and field test data.

What this thing does is it uses a color graphics display system with a map background. We get to replay the battle on a map background. We use the Janus symbol editor so you can actually have tank symbols up there instead of little dots, and you are able to zoom, put grids on, scale, do all kinds of neat things. What it really is, though, is an interactive color graphic relational data base. I used to have to thumb through pounds of paper to find all of the red tanks killed by nuclear weapons of a certain kilotonnage. Here, you ask for that and they appear on the screen. Want to know something about a particular guy, like why was he killed? Put the cursor on him and push a button, and you get an alphanumeric readout that tells you how much ammunition he's got, when he was killed, why he was killed, etc.

We can operate on output from Janus, and we have extensively modeled NTC data. We have used actual training center data and field test data. We have put both Janus data and ConMod data up on a single Janus screen. By the way, ConMod is written in Ada, while Janus is in FORTRAN. This doesn't make any difference for the system. The system can show you all of the red systems killed in the first 30 minutes of some simulated battle, and the types of kills are color coded. You can tell who was killed by whom, and see the direct lines of fire. The system can show all the red and blue artillery impacts, and the damage they produced.

We showed this stuff to General Mullin at Fort Leavenworth. He really liked it, got excited about it, and asked if we could engage Janus in the middle of one of these displays and do "what if" games. In other words, play different tactics. We indicated that the system was not designed for that capability, but that we'd think about it. Two days later we were able to push a button at any point in time during the analysis, and engage Janus to play alternative tactics. We then presented it to General Thurmon, who is the Commanding General of TRADOC, and he really liked it. There is now a lot of interest in training applications with a combination of these products.

I presume the Army is going to use something like this system at the Precommanders course, the Precommanders Staff College, and the Nuclear Weapons Officers course. These are the only groups that really play nuclear weapons in a high

Analysis Of Interactive Wargames Has Been A Problem

- Difficult to understand wargame results using traditional output methods and data.
  - Effects of terrain.
  - Player variability
  - Free play tactics
- Controller is required to monitor game and explain results.
  - Multiple player stations
  - Remote players
- Lack of recorded information to challenge or support controller.
- Game replay is not the answer.
  - Information saturation
  - Each view is only a perception
  - Multiple views
  - Run time degradation on shared systems

Conflict Simulation Laboratory   Lawrence Livermore National Laboratory

Requirements For AWS Development

- Minimize development costs by exploiting existing Janus software to the maximum extent.
- Employ the same hardware suite as Janus.
- No detailed knowledge of database management systems FRAMIS or INGRES required.
- Events to be displayed by time, side and task force.
- Event displays can be selectively overlayed and edited.
- Alphanumeric event reports retrieved and displayed by graphically picking the event symbol.
- The design to be as generic as possible .
  - Applicable to other models
  - Be able to process field test and exercise data

AWS Features High Resolution Interactive Color Graphics Displays

- The Janus Terrain Editor has been incorporated into AWS to provide a capability to generate terrain and map displays using DMA or similiar data.

- The Janus Symbol Editor has been incorporated into AWS to allow the user to define up to 100 symbols.

- AWS interactive functions include:
  - Query plots
  - Overlay of different events
  - Selective deletion of displayed events
  - Terrain zoom
  - UTM grid display overlay
  - Scaling of symbol size
  - Change data files

The Purpose And Goal Of The Analyst Workstation

- The purpose of this project was to develop an interactive color graphics based post-proccessor which would allow an analyst to selectively display the time-phased and positional events of an interactive wargame overlayed on a map and terrain display.
- The goal was to enable an analyst to understand the wargame, based on recorded data, better than the players and controllers who participated.

AWS Has Been Exercised On Three Data Sets

Janus scenario	- 3 hours of combat	
Datevent.dat -	10,000	records
Datspot.dat -	9,000	"
NTC data - 7 hours of combat		
Positions -	24,000	records
Artillery -	200	"
Effects -	1,000	"
Engagements -	2,000	"
ConMod demo - 40 minutes of combat		
Movement -	200	records
Acquisition -	100	"

New Product Will Permit Systematic Validation

- Provides tool for easy comparison of FTX and Janus results.

  - FTX provides real data to help validate acquisition, movement, and firing rule models in Janus.
  - Janus provides engineering level weapons models to help validate FTX weapons systems simulators and other data collection systems.

- Iterative process of validation will influence the collection of FTX data to support analysis and benchmarking of simulation models.

- Validation process will be particularly helpful for validating automated planning concepts for ConMod.

Recent Developments

- The Analyst Workstation has been modified to interface with Janus.
  - A capability has been developed to create a scenario file that can be processed by Janus.
  - A specific time can be associated with a scenario being displayed on AWS so that Janus can be executed from that time forward.
  - The cabability is in prototype form at this point in time.

- In addition to being able to analyse field exercise data such as NTC data the prototype permits alternative tactics to played and evaluated from the specified time, on Janus.

- Training applications of a final product based on the prototype concept include:
  - Permits commanders to perform "what if" studies,
  - Is a cost effective means of replicating training exercises to provide reinforced learning,
  - Training can be conducted at any site equipped with Janus system, including schools,
  - Provides training in a less threatening environment than an FTX. Commanders can experiment with bold and innovative tactics without feeling that their career is at stake.

Training Applications Of Janus and AWS

- Useful tool for training at Army schools such as CGSC courses PCC and NWOC.
- To train commanders on their terrain before and after assuming a field command.
- To train commanders prior to participating in a CPX or FTX using the exercise terrain.
- To Train commanders in opposing force doctrinal options.

resolution environment. They are going to be using this system right after the first of the year.

Validation was another point Captain Jones made. With the analyst work station and Janus living and breathing in the same environment, for the first time we can balance field test exercises against the combat simulation, run them in an integrative fashion, and fix the models that aren't right.

I am working with Bill Wasser and Dr. Bryce at what used to be SEADAK at Fort Ord. They want acquisition tests; very high resolution tests. We are going to be able to run acquisition data through this system, see where the acquisitions were made, then run Janus on the same scenario, and see where the acquisition model made the acquisitions. In this way we can see if there is any similarity at all between the theoretical model and what people really did. This effort may not only allow us to fix the combat model, but we might also be able to encourage the field test guys to take the right data so that everybody uses the same basis.

I only have a couple more charts that I use to tell people what we have been doing lately. We have put out a whole new set of documentation and released something called Janus 4.0. We have installed it at five new sites. We are now operating on things like the MicroSAINT 3500, the MicroSAINT Station 3500, the 6220, a VAX 8900 and 600, and any MicroVAX DEC machine. We have revised and improved the analysis work station. Previously, we had to use INGRES or FRAMIS data base to get data. Now we no longer have to do that. We now are able to import FORTRAN data files right out of Janus. The upshot of that is the INGRES license (which costs nearly as much as the little computer) is no longer needed, and cost can be significantly reduced.

Recently, we ran Janus here for the Army as part of mission area analysis doing what was called a nuclear excursion study involving DNA and the Army. We ran the biggest game ever run on Janus, there were actually 4,300 individual item systems. This is roughly what you might consider as a blue division against the red division. It was a big game. Very successful. There are some papers being written on that exercise.

We have done some off-site demonstrations. This is fairly new. We are able to take a machine the size of a couple of terminals, put them on an airplane, and go somewhere and put on a demo. We have done this for General Mullen, and General Thurman at the Pentagon.

Our users' conference, (analogous to this meeting) had about 60 participants. There were 20 some papers given over three days. I think there was a paper given by a Marine, two papers given by Navy people, and several efforts by Naval Postgrad School.

My last chart deals with future plans. It's a little bit dated already.

We are modeling (among other things) special munitions here, particularly MLRSTGW for the Office of Munitions. In doing so we found some difficulties in the line of sight operations, which we think is the best one known to man, but it isn't good yet. There is a trade-off between compute time and accuracy, and we have some ideas that we are going to be implementing.

When you get to large games like the division game, we have a control problem. Janus was not set up to control big units, so we are going to have to use some form of templating. We currently control at the platoon and combat levels, and we need to control at a slightly higher level in order to do a bigger game. Currently Janus plays on a 400 by 400 grid, and you get to pick the grid size, depending on your needs. We have increased that to a thousand and probably could go quite a bit higher. It's more of a memory issue than it is anything else, and there is lots of memory these days.

Internally we are doing quite a bit of work here inside the lab for the first time. We have convinced the outside world to use it, and now we almost have the lab convinced to use Janus. That's a real breakthrough. They have some pretty exotic weapon studies going on here that are line of sight type weapons. So three dimensional terrain and having a combat environment is important.

(Brief recess taken).

CDR BERGHAGE: Sorry to call you back early from your coffee break, but there was an addition to Janus that we wanted to cover, and in order to work that into the time schedule, we had to cut the coffee break short.

Janus Highlights Since November 1987

- Released Janus 4.0 along with improved documentation.
- Installed Janus at Five New Sites.
- Janus Now Operates on a Wider Spectrum of Hardware.
  - Tektronix 4225 now standard on all new installations
  - Operated Janus on wider spectrum of host computers, including VAX-Station 2000, MicroVAX 3500 and VAX 8800.
- Analyst Workstation 2.0 Now in Prototype Form.
- Conducted Division Level Game Involving more than 4000 Individual Item Systems.
- Conducted 77 Separate Demonstrations of Janus and AWS for LLNL visitors.
- Conducted Four Off-Site Demonstrations for the US Army:
  - BG. W. Mullen at TRAC-Monterey
  - Gen. M. Thurman at the Pentagon
  - MG. T. Tait, MG. G. Sullivan, BG. J. Tillelli at the Armor Conference, Ft. Knox.
  - Gen. M. Thurman and Staff at Ft. Leavenworth.
- Held annual Users Conference involving more than sixty participants presenting twenty one papers over three days.

Conflict Simulation Center **Lawrence Livermore National Laboratory**

Future Plans for Janus

- Janus enhancement activity.
  - New line-of-sight algorithm
  - Update nuclear effects models including new DNA Intermediate Dose Model
  - Add low level forces templating
  - Increase grid size
  - Other selected product improvements

- Encourage and expand LLNL use of Janus for studies.
  - Conventional arms control
  - Advanced conventional weapons
  - Exotic weapons

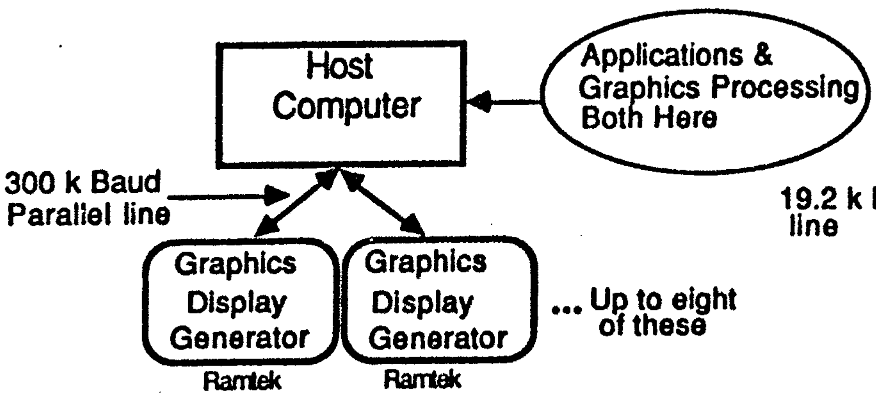
- Encourage the continued use of Janus by installing systems at other agency sites.

- Combat model validation.
  - Work with USA Test & Experimentation Center (Ft. Ord.) to conduct research on validation of sub-models such as acquisition, line of sight, movement, firing rules, ...

- Continue to support Army training initiatives to insure the use of a high quality simulation.
  - The Thurman initiative to use Janus for both analysis and training for the Tactical Commander's Development Program
  - Embed Janus in the Army Family of Simulations (FAMSIM) Program
  - Embed Janus in Battle Commanders Training (BCTP) Program

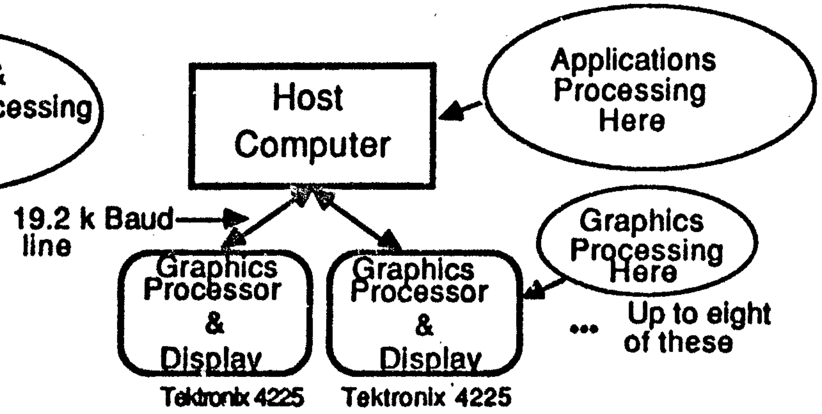
Janus Architectural Improvement Since 1983

Single Computer (1983)



- Graphics processing on host limits throughput
- 300 k Baud parallel line has restricted length
- Run time of system strong function of number of terminals
- Graphics code mixed with applications code

Distributed System (Current)



- Local graphics processing provides improved run time performance
- 19.2k Baud line permits use of telephone lines
- Performance is a weak function of number of terminals
- Graphics code decoupled from physics code to allow easy migration to future new hardware

Human Performance Models In Janus

- Performance Rates
  - obstacle clearing
  - mount/dismount
  - logistics transfer
- Pop Up Function
- Forward Observer

- Weapon Systems Degradation
  - movement
  - acquisition
  - response time
  - reload time
  - probability of hit

Performance Degradation Sources Modeled

- Beam Weapons
- Mission Oriented Protective Posture
- Radiation
- Suppression (partially modeled)

Popup Is A Combination Of Human Limitations And Tactics

- State Change Timing
  - full to partial deffilade
  - set up to shoot
  - to clear position
  - partial to full defilade
  - stay in full defilade

- Return To Full Defilade
  - rounds fired
  - time exposed
  - P_k when shot at

The next speaker is George Anno; he is going to talk about Crew III, which is an addition to the Janus model for handling the human factor types of information.

ADDRESS BY MR. GEORGE ANNO

MR. ANNO: First of all, I am going to mention that I am part of the IDP Mafia, of which Dennis Kelleher was an early member. I notice most of this Mafia sitting over here on the left side grinning. The godfather is over there, and he has the largest grin on his face. Dr. Young from DNA (Defense Nuclear Agency) has supervised and led this process from its start.

The need was basically established through the U. S. Nuclear and Chemical Agency, under the direction of the Army, who is interested in developing manuals and training aids, etc. for the TRADOC organization. We had a meeting with the TRADOC people, and they gave us a lot of insight regarding what we should be looking at in terms of our tactical battle field situation. We couldn't do all the various elements; the helicopters, the medical people, the rear echelons, etc. So we asked them what were the important battle field elements that we should really be looking at in order to characterize the situation? They came up with four different crews. Actually, three, but there is a composite one. They came up with the tank, the tow, the tow vehicle and artillery, whose elements are the Fire Direction Center (FDC) and also the gun crews. Each one of those small units has four crews and four crew members except for the FDC; they have three. So what we wanted to do was to model those small elements. Prior to this we had talked to the Janus people and they indicated that they just look at the movement of units. What we want to do was to look at the performance of these crews by combining the degradations of the various crew members within the small tactical unit. We wanted to look at how the crew members worked together, how they did their various jobs, and how well they coordinated their efforts.

The first thing we had to do was to try to establish how are were going to evaluate the radiation insults, and how those insults propagate from a radiation exposure. So how do we actually characterize those insults? We decided to characterize the insults in terms of the symptomatologies that would develop. For example, the upper GI syndrome, the vomiting, the nausea, the lower GI syndrome, diarrhea, fatigability, weakness, fluid loss and all the bad things that really degrade performance. Where can we get this data? A lot of it had been generated prior to this project, but it existed in bits and pieces here and there among the various parts of the military.

Colonel Pickering, for example, did an enormous amount of work for the Air Force in making these kinds of assessments for armor crews, fighter aircraft, and attack aircraft. So we also went to Dr. Pickering and talked to him about this issue. There were various other individuals that were in the group that helped develop this IDP process. They came from various areas of the military, the medical community, universities, and the national laboratories.

We sort of went through a process of multidisciplinary guidance so that we would establish this. As we established the symptomatology we developed those parameters that described symptomatology progression such as the onset of the problem post irradiation. That is, an acute pulse from let's say an atomic weapon, how quick or how fast these symptoms would develop, how severe they would get in what time frame, and how long they would last. The information that we used to develop the IDP was sort of a kaleidoscope of things. We got information based on nuclear accidents in industry. There has been something like 100 accidents, and maybe about 40 of them are more or less useful in the dose range that we are interested in. The IDP intermediate dose basically covers a range of somewhere between 75 to 4500 rads. This range more or less set the tone for the levels of performance degradation we looked at and focused on. All of this work of course is looking forward to trying to develop a crew model ultimately. We got information from the nuclear accidents, therapy patients, and various clinical institutions around the United States and the rest of the world. We also looked at the Japanese atomic bombings (the experience there), and bomb test accidents from the Pacific testing sites.

We also looked at animal data from the standpoint of performance, particularly the heat side, which is the early transient incapacitation of animals. We are pretty sure humans suffer the same effect. We have seen this in two accidents. We obviously cannot perform an experimental study using human beings, so we are looking at retrospective data and trying to sort it out. It's quite a hodgepodge of information. We were quite successful in establishing a dose time map of these various symptom groups. We have divided the symptoms into six different groups, and I can get into that more later.

These symptoms more or less describe the initial stage, that is to say, the initial response when sickness comes on anywhere from a few hours or to where you get maybe 3,000 rad, and the onset is within about 15 minutes. For lower doses the onset is sort of an insidious thing that develops over a period of two or three days and sort of levels out, depending on the dose. After the initial stage there is another period which comes on days to weeks later, which is known, as some of you are familiar with, as the hemopoietic effects. Eplasia in the blood system develops, and I think we have seen a lot of that from the Chernobyl accident. Incidentally, the Chernobyl incident has provided us an opportunity to verify our symptomatology assessment.

The next step we needed to perform was to take our symptomatology descriptions, and put them into some plain words that people would understand. Once this was accomplished we took our list to the military crews that we had selected, that is, the tank, the tow vehicle, and so forth. We went to various military installations to interview experienced people who had actually had some experience in combat, Vietnam and/or Korea. We wanted individuals who had experience with the equipment and knew how troops would function in a situation where they were seriously degraded. We wanted to know how they felt the various symptomatology would lengthen the time to perform the combat task.

We used the "performance time" parameter because when we asked troops about accuracy and that sort of thing, they said, "Well, hell. We just put a shell in the breach and we just keep crashing it in until it goes in." There is not much of an accuracy issue there at all. The only system that really had an accuracy issue was the TOW wire guided missile, which you have to keep guiding to the target. We were convinced that the time extension for completing these tasks was the important parameter, and we stuck with that. To quantify the subjective responses we wanted to use the Delphi technique, so we talked to the inventor of the Delphi process at the Rand Corporation.

What we ended up with is basically a self evaluation process where you are asked to make judgments on how much time a task would be extended if the following symptoms were present. In describing the symptoms we struggled with the terms in order to make sure that these Army guys understood in plain language what we were talking about. We used "coming down with the flu" as one of the key descriptions so that they could relate their experience to the symptomatology found in radiation victims. Most of the troops could easily relate to vomiting, nausea, and the other symptoms from personal experience. The questionnaire process gave us the data that we needed to relate the symptomatology to performance decrements.

Each individual interviewed gave us their individual judgments regarding the lengthened time required to perform a given task, or whether they could perform it at all. The anchor points on the questionnaire were: "I couldn't do it at all." or, "It wouldn't be any problem whatsoever." We also obtained field measurements to determine the normal time that it took to do all these jobs. These were done at the various Army centers around the country, such as Fort Knox and Fort Benning. The troops performed simulator tests, and also some field tests to develop the normal base times and variances for the selected tasks.

The statistical analysis of these timed tasks has developed into what is now called the "Crew III" model. The Crew III model, as it has developed, has become a module for inclusion in the Janus program. It is important to remember that the Crew III model is a process. It's not like a SAINT model, that is, a canned situation, where you can j[illegible] sort of overlay and put things in. Crew III is not that general. You have to sit down and draw diagrams out, you have to develop a process for a period of time. Basically it's a period of time flow chart or event analysis. We have performed the analysis for the four selected crews tasks. Each one of the periods selected for analysis was a critical part of mission. We took critical performance times and related them to the dose response time curve. The integration of this relationship is the basis of the Crew III model, which is being used in Janus.

MR. BANKS: I would like to introduce the next speaker to you. He is Bob Terhune from the Lawrence Livermore National Laboratory; he will talk to you about a relatively new model called SEES. It has an orientation towards special warfare. It can be used for small force on force engagements, and terrorist activities.

ADDRESS BY MR. ROBERT W. TERHUNE

MR. TERHUNE: What we are going to talk about is the development of a site security model. We are trying to model humans in small arms combat. That's the area I am going to try to focus on for this presentation. We have been working on this program for two years now. One of the first things we did was build a prototype from Janus. We took Janus, modified it, and built a prototype to demonstrate the concept. The rest of the time, until just recently, we have been in what we call the requirement and analysis phase. We are putting in an awful lot of effort up front working with the prototype and working with the PSO guards to develop the requirements and the information that we need to understand the problems before we go into coding or a design phase.

OSE, the Office of Security Evaluations, has asked us to provide a means for a site to enhance its security. They wanted to conduct force on force exercises for the evaluation of the security force performance. They also wanted a means to supplement their training program in Command Control, Communications and Tactics for PSOs, sergeants, lieutenants, and the security inspectors. We felt a model based on Janus, but using small arms combat would be the most ideal thing to do. It was this concept that we actually named the model after the "Security Exercise Evaluation Simulation" (SEES).

A force on force exercise involves a group, essentially a SWAT team, acting in the role of terrorists, trying to penetrate laboratory security. They sneak into the laboratory at odd hours and try to take over the facility. The object of the exercise is to see how well the security force here at the laboratory responds to the threat. They use MILES gear and it gets pretty realistic. It would be nice to be able to simulate the exercise, because it's very expensive to carry them out month after month. We wanted something that would help us to simulate this process, and allow us to supplement some of these exercises with a computer simulation.

SEES Project
Developing a Site Physical Security Model

Project Review

Presentation by:
Robert W. Terhune
D-Division, LLNL

Conflict Simulation Center   Lawrence Livermore National Laboratory

We are in the process of developing a Site Physical Security Computer Model. This model is called the Security Exercise Evaluation System. This presentation is a review of the SEES project. We will present the SEES review in the following order.

- The goal motivating the development of the model.
- A brief description of the model.
- A description of the data requirements.
- Examples of how the model can be used.
- The development plan for the SEES model.
- The capabilities of our current prototype.
- Additional features being added to our next version.
- Summary.

Historical Background

Sept 86 Julio Torres, DOE, Director Office of Security Evaluations, requested LLNL to develop a simulation that would provide a broader baseline for evaluating site security force performance where the rating is based on a mixture of simulations and actual field test exercises.

Nov 86 Modified the Janus combat model to prototype a security model.

- 4 meter resolution.
- Trees for buildings, trees and natural barriers for walls.
- Rivers for fences, abatis for doors
- Tanks for people, sensors for CCTV cameras.
- Weapons - LAWs, automatic rifles.

Historical Background

March 87 Completed SEES user requirements.

August 87 Completed prototype for terrain editor and SEES 1.0

- 0.1 meter resolution
- Buildings, walls, doors and fences as objects.
- Robot like human model.
- Weapons - LAWs, pistols, automatic rifle.

May 88 Used SEES for planning and analysis of Force on Force field exercise.

October 88 Completed SEES analysis and design

- Information model, State diagrams.

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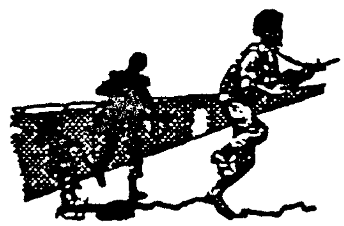
Model is Supported by OSE to Simulate the Security Force on Force Field Exercise

- Provide a means for a site to enhance and focus the use of force on force exercises in evaluation of its security force performance.
- Provide a means to supplement the training program for security inspectors in command, control, communications and tactics.



- This concept led to the model's name of Security Exercise Evaluation Simulation. (SEES)

Conflict Simulation Center   Lawrence Livermore National Laboratory

The director of OSE came to LLNL with a request to develop a model which would simulate a Security Force on Force Field Exercise. The purpose was to provide a broader baseline for evaluating site security force performance where the rating is based on a mixture of simulations and actual field test experience.

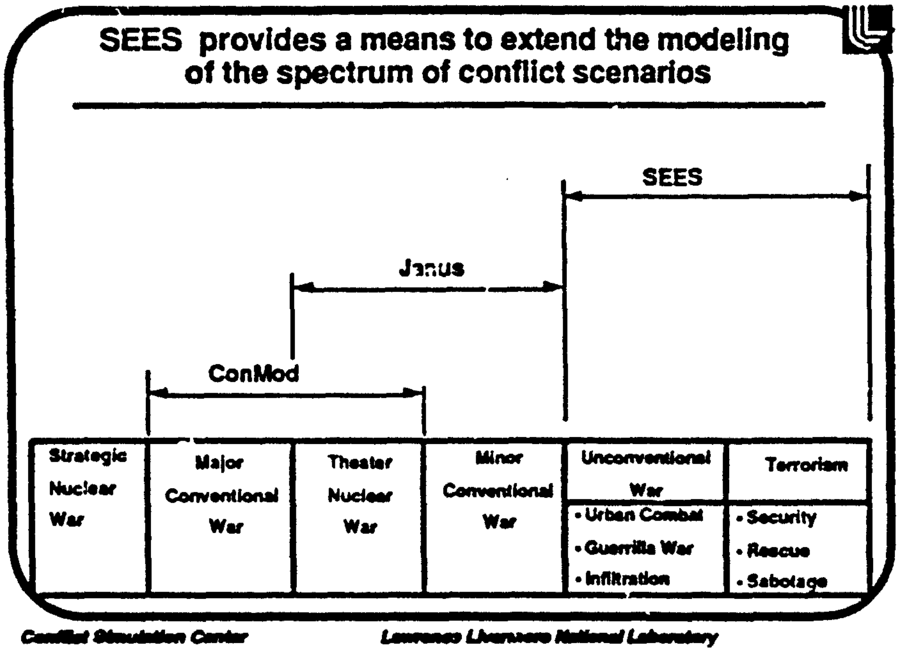
We named the model the Security Exercise Evaluation Simulation (SEES)

The figure lays out the spectrum of conflict scenarios that we are trying to cover. ConMod covers very large engagements. Janus, of course, is kind of an in between model. SEES is designed for combat in a highly detailed area like urban combat, gorilla war, infiltration problems, security problems, rescue and sabotage.

Right now our primary focus is on the security area, because that's where our funding is focused, but we are willing to explore other applications as people decide that they want to fund the development of these areas. SEES is being designed to model all aspects of an armed intrusion against a secure site. In SEES, we are modeling buildings of various heights, and also the interiors of the buildings. We are modeling such things as fences, different types of terrain or ground surfaces, TV camera surveillance, and alarm systems. But most importantly, we are modeling people, and we are modeling people engaged in combat. We are modeling people doing tasks such as breaching a fence, climbing a fence, running, acquisition or targeting and searching. We are modeling people dealing with various types of equipment such as gas masks, binoculars, etc. These are the types of things that we are trying to model.

The thing that you really need to model this stuff is data. You have to have a tie-in with the real world. We feel that measured data and expert opinion are going to be the key to SEES' realism. We are trying to model the physics of events supported by measured data, especially in areas such as acquisition, movement, barrier penetration, targeting, and other performance skills. We are trying to develop SEES with the consultation and advice of numerous organizations with expert knowledge in weapons, small arms, combat, maps, terrain effects, security, safeguards and human performance. We are using expertise at CTA, the DOE training academy in Albuquerque for security inspectors. We are trying to arrange an agreement with the U. S. Military Police School to provide them a SEES model, so they can begin using the system. They can provide us with feedback on the model's accuracy, and provide us with data on combat.

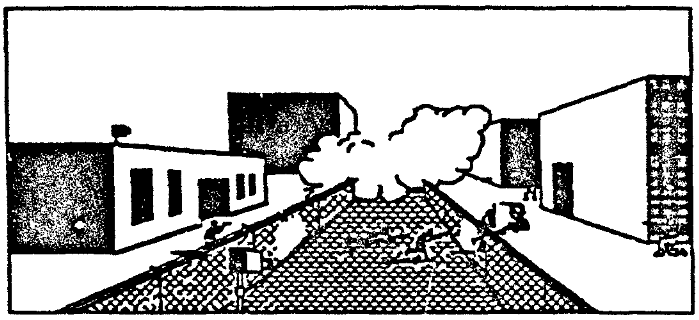
We are working very closely with our own PSOs here at Livermore. They actually come in and work the prototype and give us input on what works and what doesn't. We have had contact with AMSAA, and we work with them in order to use the Army approved data for the various weapons' effects. We have also worked with the U. S. Army Topographical Laboratory in terms of the environment, and the terrain.



The Conflict Simulation Center had developed a battalion size model for mechanized combat in Janus and was developing the requirements for a Corps size Battle management model.

SEES provided a means to extend the model to simulate Unconventional War and detailed small engagements. While the consequences of any single terrorist act is relatively small, the large number of incidences makes it a significant factor in the spectrum of conflict scenarios.

SEES is being designed to model all aspects of an armed intrusion against a secure site



- Characterized as a high resolution, event sequenced, stochastic, two sided, interactive, graphic simulator.

Conflict Simulation Center — Lawrence Livermore National Laboratory

SEES is a highly detailed small arms combat model. This picture represents many of the aspects of an armed intrusion against a secure site that can be modeled with SEES. Intruders armed with various weapons have cut through an alarmed fence, slowly crossed an assessment area, cut through a second alarmed fence to enter the secure area. Sensors on the fences and within the assessment area have triggered the alarms and the intrusion is verified with CCTV cameras. Guards have responded to the alarms to engage the intruders.

Simple terrain features such as fields and roads are modeled. Fences, walls, and doors are modeled as breachable barriers. Breaching is modeled as a time delay based on the data for each barrier type from the Barrier Technology Handbook, Sand77-0777rev 1987.

Site characteristic data are developed using a terrain editor, which provides a quick method digitizing from a map of the site and assigning attributes to each object. The LLNL digitized site consists of about 14 miles of road, 500 exterior buildings, 5 miles of fence, and one interior building inside of one square mile. It took about four days to put the site characteristic input data for the Livermore site into the computer. Periodic updates take about one half hour.

SEES is characterized as a high resolution, event sequenced, stochastic, two sided, interactive, graphic simulator.

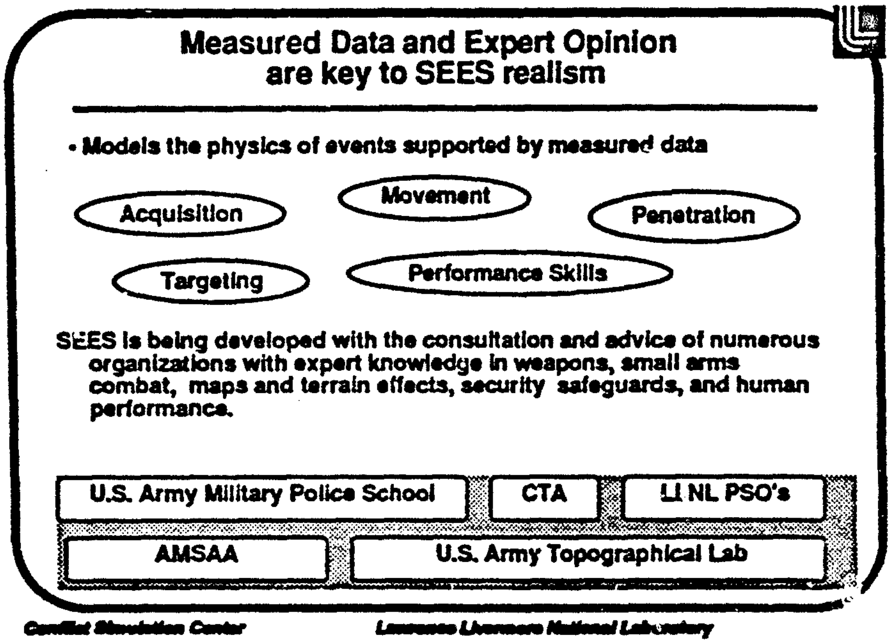
Our philosophy is that SEES will be based on individual performance data, and tested against field exercise observations. We take a group of individuals and run them through a performance test. We take 80 guys and run them 40 yards and, time them. We have a distribution of how long it takes those 80 guys to run 40 yards. We are going to do the same thing for a mile, a half mile, and so forth. You run them through these performance tests and you get distribution parameters. From those distribution parameters, we derive the input for the model.

After the input we do a SEES simulation of a force-on-force exercise, and we get certain outcomes. Now we go into the field and we take the same group of individuals and we put them through different tasks. It's a force-on-force field exercise. We go out, make the observations of that exercise based upon the same plan that we used in the force-on-force simulation. We come back and we analyze the data, we compare the observations here with some of the simulation outcomes. This comparison indicates where we are good and where we are bad, where we have missed the mark, and where we have hit it. As new specifications are developed, we modify the model and then repeat the testing process again.

Another thing that's nice about this is that we are really modeling a simulation in a sense. This gives us a stepping stone into looking at real data, because we can go out and measure what these guys do in a force-on-force exercise. If we can take that force on force exercise and model it in the simulation, then we can use our model for making estimates of real world situation. What the model is lacking is good data on how people perform the tasks, and on the time it takes to complete various tasks. We have actually measured data from DOE on how long it takes to go through barriers using certain tools, and we use this type of data in the actual model.

One of the things that we are developing now is a physical exertion model. The model is simple, but realistic.

I mentioned earlier that we ran all the PSOs here at the laboratory and collected measurements for the times to run 40 yards. We did the same thing at a half a mile, and also in a mile. The next figure shows the results. The two parallel lines were obtained from standard handbooks and record books. The top line is a four mile-an-hour walk at a constant rate. People don't seem to tire over that distance. The bottom line indicates world record times for various distances. The linear nature of



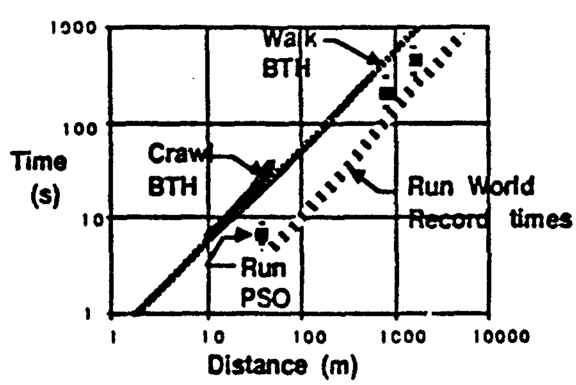
SEES models the physics of events, supported by measured data. Acquisition of targets are based on field experiments involving hundreds of soldiers viewing stationary and moving targets on a terrain with various degrees of clutter. Movement is based on time - distance performance tests of protective service officers. The methods and times required to penetrate doors, walls and fences are based on actual field tests by Sandia Laboratory, Albq., for DOE and published in the Barrier Technical Handbook.

SEES is being developed with the consultation and advice of numerous organizations with expert knowledge in weapons, small arms combat, maps and terrain effects, security safeguards, and human performance. These organizations are expected to be users of the model, generate data for the model within their expertise, and provide expert opinions on the model's performance.

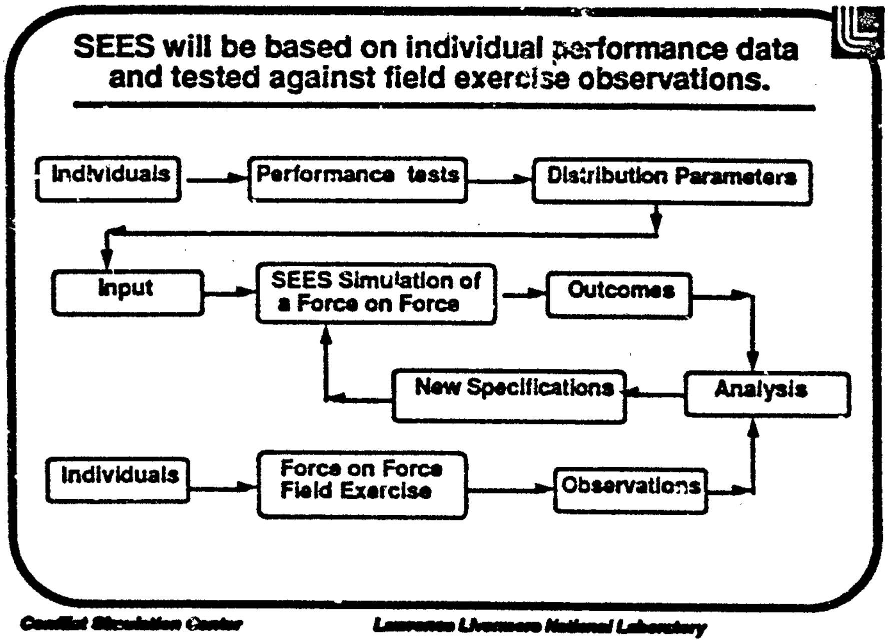
SEES simulation of real life behavior will be confirmed using individual performance test data, and observations from field exercises.

Physical exertion model for phase 2 is simple but realistic.

Phase 2 Mobility Model



BTH = Barrier Technical Handbook



SEES is being developed to take measured performance data and use it directly for data input and system parameter values. Distribution parameters will allow stochastic variation of performance between repeated events. We plan to complete the loop of measured individual performance input into SEES then simulate actual field exercises, compare the simulation outcomes with field observations, modify the model, and repeat the process until the model meets the expectations of experts in physical security, urban combat, and human performance.

A force on force field exercise was recently planned using the SEES simulator , and data collected from the field exercise was used to test and improve the behavior of the prototype. We identified that combat in the field was considerably less intense than the simulated combat. This occurred because SEES did not model engagement from cover. We put a prototype "engagement from cover model" into SEES and found a considerable difference in the casualty rate on both sides as was observed in the field exercise.

The SEES project needs human performance data on endurance and fatigue and the benefits of rest in a number of areas such as movement, detection, and combat performance.

these relationships allows us to interpolate the times for distances not actually measured.

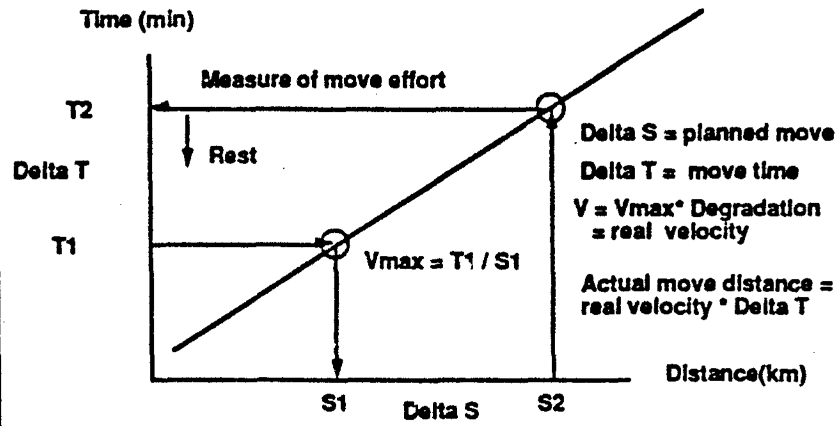
Based on this information we developed a simple algorithm to account for the effect of being tired and fatigued. This is not a sophisticated model of fatigue. We are just trying to account for its effect in some way. We are in the stone age here with this type of modeling. This is intended to get us going. This is not where we want to be. This algorithm gives us the effect of the distance-time relationship. As you go farther and farther, you slow down. You cannot sprint for a long distance. We have also incorporated a very simple rule of thumb model that we picked up from our physiologists here at the Laboratory. They indicate that it takes roughly three minutes of rest in order to get a minute's benefit on our curve.

These are very simple models to get us started. I want to emphasize that what we need is a real movement model. We hope that something like this would evolve to where we can use the rate that energy is expended and compare this with various factors such as terrain posture, running, walking, sprinting or whatever. It would be nice to be able to get the amount of energy expended to do these tasks, and then compare it to an endurance rate, where the endurance is the energy expended as a function of time.

We are trying to do a similar thing for modeling target acquisition. We used information based on experimental data obtained by the U. S. Army. They took 90 stationary observers and had single individuals move along a path at various speeds. They went across walking, a slow run, and a fast run. At a certain point in time, observers had line of sight view to these individuals. The Army measured how long it took to detect the individuals. We took this data and they worked it up using linear regression into a log normal distribution. We were able to take this distribution and develop an algorithm that allows us to predict how long it will take to make a line of sight acquisition. This is the type of thing we are going to try to put in the model. One of our basic objectives is to do research with each phase of the project, and the acquisition model is this year's research problem.

We are also going to try to model human performance skill levels by using performance distribution data. We take a performance skill and get a measure of the average performance of a group, along with a measure of variance. We use this performance skill distribution to perform Monte Carlo simulations. We do a random

Movement algorithm is simple and based on measured data



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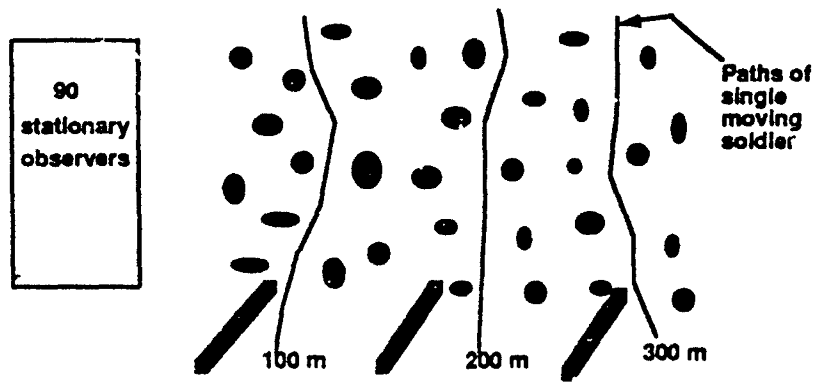
The model for acquisition is based on experimental data obtained by US Army.

Crossing speed : Walking, slow run, and fast run.



Measured variable is time from LOS to detection

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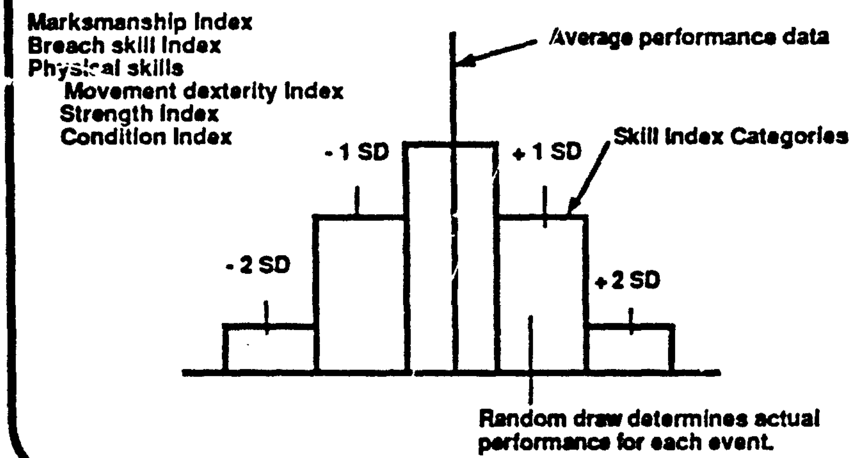
draw-out to determine the actual performance of each event. The results of any particular event could vary depending on the performance that one gets on the random draw. Our model gives the analyst control of how good he wants his people to be. He can model them all as supermen, or he can make them average, or he can make them wimps, whatever he desires.

As part of our program we are developing utilities for Janus that will simplify the data acquisition and input process. The terrain editor we have allows us to use the barrier handbook and a site map to digitize the LLNL site and specified barrier attributes in about four days. I might just mention that this site is about one square mile, and includes 14 miles of road, about five miles of fence, 500 exterior buildings and one building interior. Using the Army master PH/PK data base we were able to define weapon target relationships in about three hours. This included three weapon types and eight different target types. Using the barrier handbook and time distance studies we were able, using the scenario editor, to define human performance scenarios in about one day. It doesn't take a long time to develop a data model, and the new editors will be more advanced than the group we have right now.

Perhaps one of the most important questions is, how can the model be used? We envision the model being used for training in command control communication tactics. We have taken a yard sergeant who is responsible for keeping the intruders out of the laboratory, and a communications sergeant in the communications center, and let them operate the simulator. They are located in separate rooms, and communicate using their regular hand held radios. The only information they have is on their monitor screen, and the only information on the screen is of the forces and the resources that they control. So he doesn't know what this guy's forces are seeing, and this guy doesn't know what his forces are seeing. The only way they can find out what is going on is through the radio communications. The players report what's occurring on their screen so they can track and follow the intruders as they go through the laboratory.

This type of exercise has turned out to be a very effective training tool, because the model runs in real time. There are events that will overtake you if you don't make a decision now, so you can't wait around and think about it. When an event happens, you have got to decide how that's going to impact your team, make a decision for them, and get them moving in another direction or taking cover or doing something else, or they are going to get wiped out.

Human Performance skill levels are based on the performance distribution data.



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This type of exercise also provides good training in terms of the communication, and command and control. In terms of communication, they have to be very precise, and players learn to be very precise on the radio, to say very quickly what's going on and how the others should respond to the events that are occurring on the screen.

The neat thing about this type of exercise is that it has minimal data requirements, and it works well with data estimates. You don't have to be precise about the site, or all of the human performance skills, because you really are trying to train these guys on how to respond to certain situations. The training allows the students to practice essential decision making skills.

Another significant use of SEES is that it allows you to design your site. You modify your site design by using the terrain editor. You can put in whatever site characteristics you want, and then run the simulation against it. You can check such things as line of sight. This helps you evaluate site changes and check for blind spots in your surveillance. You can look at various visual barriers and assess who that cover really benefits: Does it benefit your PSOs or does it benefit the intruders? You can look at movement paths, and how the movement is going to be channeled throughout the laboratory. You can look at the design obstacles such as the ground surfaces, and see how they will affect movement. This kind of use requires detailed site data on the buildings, doors, walls and barriers for accurate site security system design. Once you have the site entered into SEES prototyping, new ideas become relatively easy.

This is one of the primary things that we built the model for: testing of detection, delay, response, and neutralization of the intruder force. One of the things that is amazing to me is the high cost of force-on-force exercises. They cost $40,000 to $50,000 apiece, and the only data they got out of them is who won or who lost, and that might depend on a secretary who happened to see the intruders come in the outside fence, called in the alarm, and the guards were waiting for the intruders. You know, strange things happen in these force-on-force exercises; $40,000 to $50,000 are spent, and very little benefit is gotten out of it. By using SEES and planning the exercise (having a real plan), you can eliminate a lot of these strange happenings.

Another thing the plan does for you is it allows you to play it on simulation as a pre-exercise briefing for your observers and your referees. In this way they know what's going to happen, and they know where and when the action is going to take place. In this way they can develop the data collection procedures that they need to

Utilities are provided to simplify the data acquisition and input process.

- Terrain editor, using Barrier handbook, site map:
  - Digitized LLNL site from map and specified attributes in 4 days
    - One square mile, 14 miles of roads, 5 miles of fence
    - 500 exterior buildings, 1building interior.
- PK editor , using U.S. Army master PH / PK data base :
  - Defined weapon - target curves in three hours.
    - Three weapons types- eight different targets types
- Scenario editor, using Barrier hand book, Time distance studies:
  - Defined all human performance and vehicle attributes in one day.
    - Five human types, three vehicle types.

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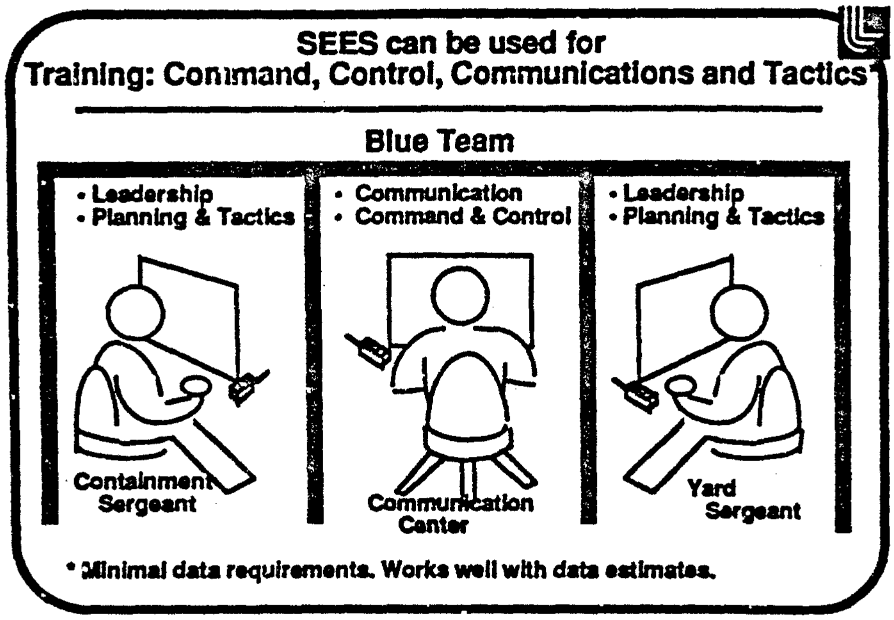
Inputting the required data into SEES is very easy and relatively fast to do. Most of the data requirements are provided with the model's sample scenario as defaults. The user can modify any of the data as they wish and the editor utilities provided with SEES allow the user to make the changes efficiently.

The Terrain editor reads the Terrain elevation data base, and set up the grid coordinates. The user can either by freehand create buildings, roads and other objects, or digitize them from a map placed on the Tektronix graph tablet. As each object is created it is given a identity number and a object type which defines its attributes. The user can specify the attributes of each object type or use the default values from the data base.

The PH / PK editor allows the user to define the probability of hit, and probability of kill for each weapon target pair he wishes to model. Default curves are provided by a master data base for most standard systems.

The Scenario editor allows the user to define for each system in the simulation; the general platform attributes, Acquisition characteristics, Combat from cover characteristics, Carrier capabilities, Engineer capabilities, Degradation effects, and Mobility parameters. Weapon systems are also defined as well their target priority.

The Scenario editor also allows the user to modify and control the performance parameters that determine the update frequencies for each event process. In addition the report frequency and output data is defined here by the user.



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SEES can also be used for training command, control, communications and tactics. In this application team members work together to defeat a common enemy. Each member has a mission and a set of forces or resources he controls.

Interacting with the simulation in real time, each member makes decisions based on the information he receives from his screen and an external radio linking the team members together. Each screen provides only the information that has been obtained by the forces or resources controlled by that workstation. Thus each member must communicate with the other team members in order to know what is happening in their area . One team member can be the commander providing direction and commands to the other team members.

The SEES simulation advances time continuously, providing a sense of urgency and stress which gives the training a degree of realism.

Data requirements for training applications are in most cases are minimal where reasonable estimates or default values can be used.

collect the information that they actually want. When the force-on-force exercise is over, they can come back and do the replay of the data analysis, do the statistics and sensitivity studies, and really begin to understand more than just the final outcome of the force on force exercise. They can understand a lot of the details of what led to the outcomes.

SEES can also be used for site security analysis and evaluation. This is one of the powers of Janus, that has come through to SEES. The system allows you to use a team of experts working together. Each member of the team works off the same information, and they try to protect the facility. Likewise, you have another team of experts working to break into the facility.

Let me go back and review a little bit for you the concepts that we are using in developing the model. First thing we did was modify the Janus combat model to provide an operational prototype. We are maintaining this prototype and updating it as we progress with the model development. We use the prototype to develop and test some of the requirements for the actual model that we are building, and we use it, of course, for demonstrations and immediate user application. We also use it to develop ideas, and to gain insight into what some of the user interface problems are. We bring in the PSOs, and train them on the system. It takes them about four days to get adjusted to the model, and then they're off and running on it. We get a lot of valuable feedback on what's easy to do and what's hard to do. We are able to adapt the total system, the menu and the graphic interface, to meet their needs.

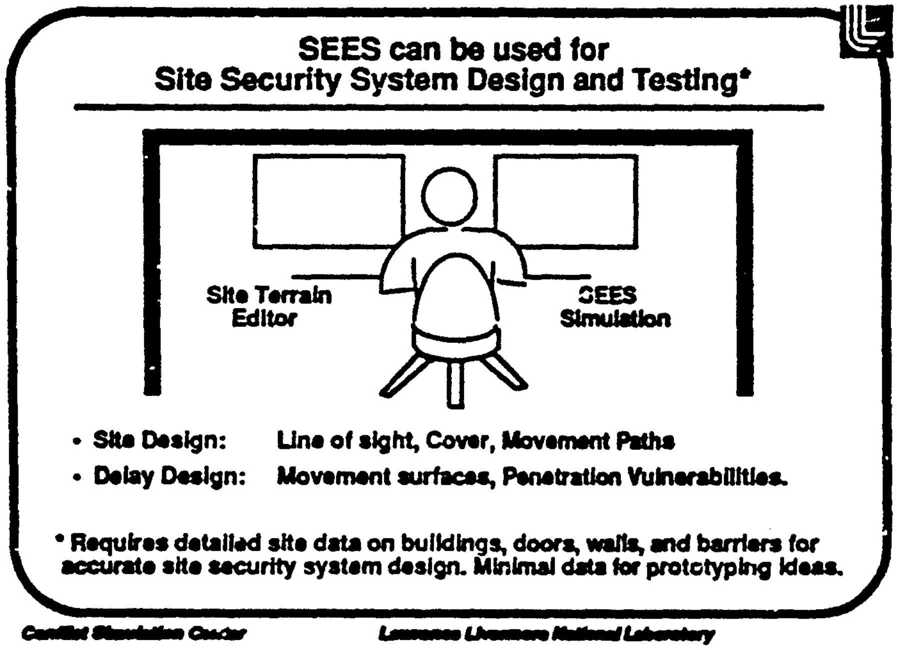
For the longer term we are designing a model using advanced software engineering methods. This model is going to be numbered 2.0 and up. It's a model where we will have full documentation which enhances maintenance and verification. Another important feature is the extensibility of the model. We are going to be able to expand this model as necessary. Its object oriented design will allow for easy modification and extensibility. I am convinced that object oriented analysis and design is the only way to do future modeling. I didn't think so a couple years ago, but I am convinced of it now. You really understand the problem when you are done, and to me that's the key of the model. The other aspect of it is you do all the work up front. You think it out before you ever go to the computer or put a word or a algorithm on a piece of paper. You understand what the data are, what the needs are, what the requirements are, what it takes to do the job. You get all those issues resolved before you go in and start coding.

We plan on developing the new model in Ada. Using this language, we hope will provide a reliable and portable model. I firmly believe that Ada is going to advance rapidly. The compilers and the speed of operation of Ada is going to advance very rapidly as the years go by, and it's going to advance in the same manner as all the hardware has advanced over the last few years.

SEES (the 1.1 which is our prototype) models most of the key processes that we feel are going to be necessary for understanding the requirements; the model terrain features such as fields, roads, fences, buildings, walls and doors. It also models human sprinting and walking (just two speeds), the detecting of targets and shooting, and assessment of those shots. Like Janus, it has item-item resolution, i.e., one soldier is able to shoot just one target individual. If he gets a kill and he has another acquisition, he must first have enough ammunition, and second, have the time to swing his rifle around and take aim. If these conditions are met, he can engage the second target.

SEES 1.1 has also given us experience modeling time delay penetration through various barriers and doors. We assume intruders can breach the doors. We know from the barrier handbook put out by DOE how long it takes based upon the type of door. In the model we make the intruder wait that length of time at the door. When the door opens, he is able to go right through. We can do the same thing with walls and fences. In SEES 1.1 we also model mounting and dismounting of vehicles. This is another attribute that we got directly from Janus. Having Janus put us a leg up on the whole modeling graphics process in a very rapid way.

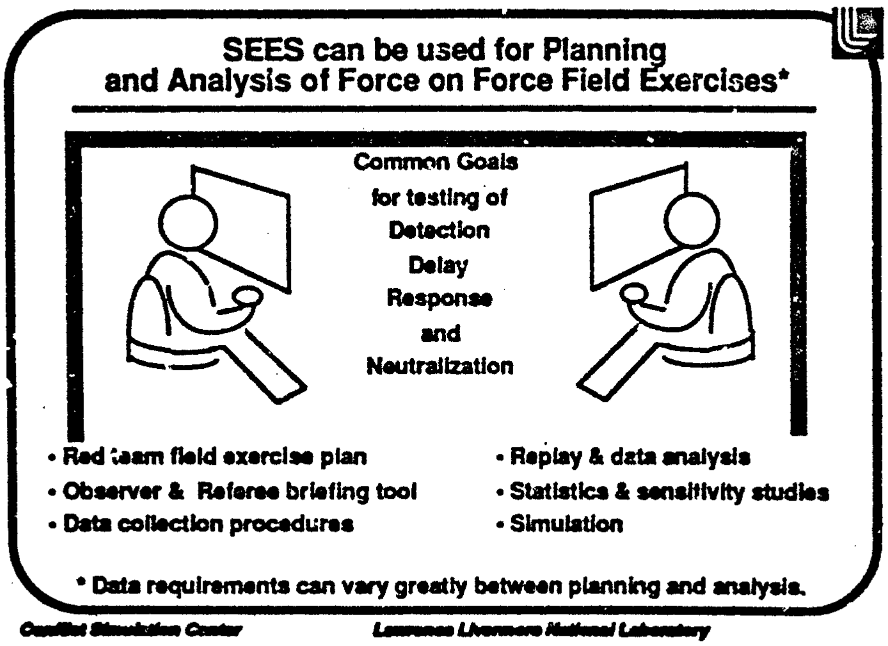
For SEES 2.0 we are going to have sequential test planning, that is, the units are going to be able to perform certain tasks that are defined in the plan as put in by the player. The units will have to carry tools and use those tools in penetrating barriers. We are going to have full cover and concealment of all objects; that is, some objects will provide you with just concealment and some will provide you with cover, and it will be dependent upon the weapon type that is being fired at you. Right now the prototype model is limited to just a single floor. In SEES 2.0 we will have multiple floor buildings where the units can travel from floor to floor. We will have three posture modes: prone, crouch, and stand; four movement modes; and two forms of firing: suppression and directed fire. We will have units carry items that they can use such as tools, weapons and special materials. As part of this feature we will have various skills levels in these three areas. We will also include a fatigue and rest model.



There are several applications that SEES is being designed for. This slide shows how SEES can be used for Site Security System Design and Testing. A single user has prepared a simulation scenario to test the security safeguards of the site. He modifies any aspect of the site including buildings, doors, sensors, and fences using the terrain editor. He then can run the simulation against the modified site looking for improvement in detection, delay, response and neutralization.

This process can be repeated varying either the scenario or the site characteristics or to develop a statistical sample for a given scenario and site version.

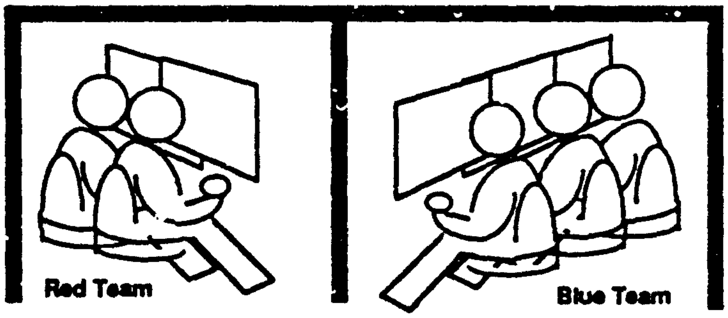
Data requirements for the site can vary from minimal effort to maximum effort depending on the application. For prototyping ideas only a minimal effort is needed. For site design or comprehensive studies considerable research and data collection may be required. The SEES model allows the user to run the model with the minimal amount of data or to put in as much detail as the user thinks is needed.



SEES has been specifically designed to provide a tool for planning and analysis of Force on Force field exercises. The adversary team uses SEES to plan the intrusion onto the site. The observers and referees use the simulation plan to determine location, timing, and types of events to be expected. The analyst uses the simulation to determine the data collection procedures, for data analysis, and to determine statistical distributions. The idea is to understand the field exercise and develop a statistical sampling consistent with the field exercise using the simulator.

Input data requirements can vary considerably depending on the degree of detail required for the analysis. Because a force on force exercise is a field simulation, many of the data details of the site can be simplified, as well as many of the human performance processes. Breaching a barrier with tools or explosives is a good example. Movement and acquisition parameters that are provided with the model are usually sufficiently accurate. Data representing the MILES equipment and the accuracy of the laser in registering a kill or near miss needs to be developed. Currently data simulating real weapons that are provided with the model are being used.

SEES can be used for
Site Security Analysis and Evaluation*



- Creative studies through competition.
- Different expertise applied simultaneously.
- Integrated studies of all aspects of physical security.

* Analysis and evaluation requires accurate data.

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SEES can also be used for Site Security Analysis and Evaluation by two opposing teams. SEES provides a team approach to problem solving where several security experts devise ways to defeat a site's security, and another team of security experts devise ways to defend the site against the threat. Here the players work together side by side, sharing the control of the simulation as well as ideas to defeat the enemy. The simulation advances in real time as each team reacts to the moves and counter moves of the other team.

Once a scenario has been developed through many interactive simulations, a statistical study can be done to develop a distribution of possible outcomes.

Data requirement for analysis and evaluation requires that considerable effort be devoted to the development and collection of data. This is especially important for the players to exercise their expertise in the various areas. The editors make the input of the data once collected, very quick and easy.

The SEES development plan provides a prototype for Now and a engineered model for the future.

- Modify the Janus Combat Model to provide an operational prototype during all stages of development. SEES 1.+
  - Develop and test requirements.
  - Demonstrations and User Application.
- Design a model with a long future using advanced Software Engineering Methods. SEES 2.+ is a model where
  - Full documentation enhances maintenance and verification
  - Object oriented analysis and design allows easy modification.
  - Ada implementation provides a reliable and portable model.

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SEES is being developed on two paths simultaneously. We first wanted to have a operating prototype as early in the project schedule as possible so that the LLNL security personnel could test the model and provide additional input for the user interface and the modeling process. Janus, a model which simulates mechanized combat, was modified to accept an urban terrain and human entities and proved to be an excellent prototype. It was in the use of the prototype and feedback from the PSO's that enabled us to develop the User's Requirements. The prototype has also been used as a demonstration vehicle to gain interest and support for the project in terms of funding, test data, and expert advice from various government agencies in the many areas we are modeling. The prototype has also been used in the first attempt to validate parts of the model by simulation of an actual force on force field exercise.

The second path is to design SEES from the ground up, using the knowledge and experience which developed Janus, in conjunction with advanced software engineering methods. This provides a modeling process that is documented at each step, where implementation of a concept is linked directly to the requirements, and the maintenance and modifiability of the code is not dependent upon a specific programmer or manager. The goal is to produce a reliable, efficient, understandable, maintainable, modifiable, portable computer code, lasting well into the 21st century.

SEES 1.1 models most key processes of site security including neutralization

Models terrain features such as fields and roads, fences, buildings, walls and doors.

Models human sprinting and walking, detecting targets, shooting and assessment, engaging from cover and direct fire suppression.

Models time delay penetration of doors, walls and fences.

Models mounting and dismounting of vehicles.

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The current version of the prototype, SEES 1.1, models most key processes of site security including neutralization.

Simple terrain features such as fields and roads are modeled. Fences, walls, and doors which are also breachable barriers are also modeled. Breaching is modeled as a time delay based on the data for each barrier type from the Barrier Technology Handbook, Sand77-0777 rev, 1987.

Human entities move at two speeds representing sprinting and walking. Acquisition of targets is based on the U.S. Army ASARS model where each human entity will detect a target after a calculated delay time from first having line of sight. The delay time is dependent on the target size, the distance to the target, and if it is moving or shooting. Line of sight must be maintained during the acquisition process. Line of sight can be blocked by the terrain elevation, buildings, walls and doors and any other solid terrain object.

After acquiring one or more enemy units, one is selected to be targeted based on priority criteria. The shooter aims and fires at the target. The shot is assessed for a hit based on a random draw against the probability of hit obtained from U.S. Army weapon's effect data. Given a hit the target is assessed for a kill with another random draw. For each weapon target pair there are PH curves as a function of range, and PK curves representing conditions or states of the shooter and target. If the target is killed the shooter selects another acquired target, or else the shooter re-aims at the current target and shoots again. He reloads from his assigned ammunition allotment when his gun is empty.

SEES 2.0 will have all the capabilities of SEES 1.1 plus

- Sequential task planning
- Cover and concealment
- Penetration with tools.
- Multiple floor buildings
- Fatigue and rest model
- Three posture modes -- prone, crouch, stand
- Four movement modes -- sprint, walk, crawl, & climb
- Suppression and Suppressive direct fire
- Carry items -- tools, weapons, special materials
- Skills - Marksmanship, endurance, & penetration

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During this current year (FY 88) the design of SEES 2.0 will be completed. FY 89 is the year that SEES 2.0 will be coded and distributed to those facilities funded by DOE to have the model. SEES 2.0 will be designed for easy maintenance and modification and will be well documented.

In addition to the considerable capabilities of the prototype, SEES 2.0 will also include the following:

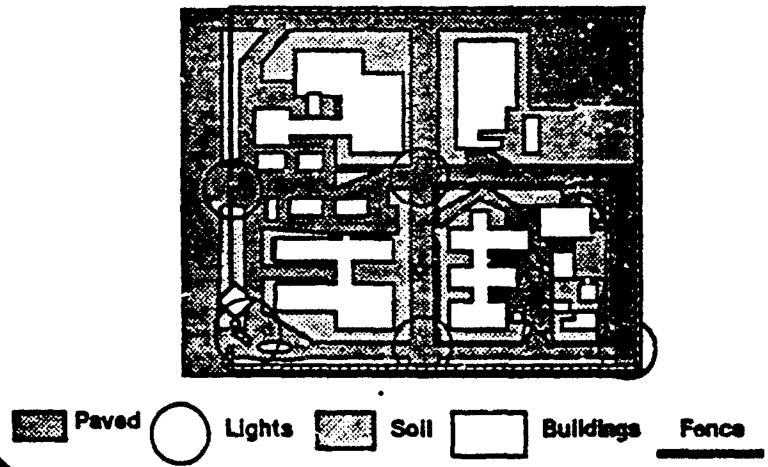
Sequential task planning that allows a sequence of tasks, such as pick up item, throw item, drop item, climb, return fire, cover fire, target object, indirect fire, change view, change gas mask, penetrate, change posture, and change speed, to be planned for each human entity in the simulation at each movement node. Each human will carry out these tasks within five degrees of skill level determined by the distribution of measured performance tests.

Cover and concealment are also modeled with the degree of cover as a function of weapon type. The time to penetrate a barrier will depend on the tools the human is carrying. The human's movement and endurance will be affected by the weight of the equipment he is carrying. Fatigue will be modeled as well as rest to cure fatigue.

Buildings will be modeled with multiple floors such that the human can move and engage through the entire building.

Humans will be able to move at three speeds as well as climb and bridge barriers, and change posture.

SEES urban terrain will model buildings, streets foliage, fences, lights, and sensors.



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SEES Project Plan FY89

• SEES 2.0 System	
* SEES terrain editor	January 89
* SEES symbols editor	March 89
* SEES PH/PK editor	March 89
* SEES characteristic editor	May 89
* SEES scenario editor	July 89
* SEES algorithm editor	July 89
* SEES simulator	August 89
• Research - Human Acquisition model	September 89

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In fiscal year 89 the simulator and all of the required support systems will be programmed in Ada. The goal here is to have a system that is easy to use, with data files available for the user to adapt or modify to meet his/her study requirements.

The model will also be fully documented with a user's manual, an algorithm manual that describes all of the algorithms used in the model.

A major portion of the plan is to do research on parts of the model that need improvement or needs to be further refined or validated with additional data and tests. For FY89 the research topic is the Acquisition Model which needs to be expanded to cover various types of sensors and detectors. Also the current model was not designed or tested for humans in close contact and needs to be refined and tested.

SEES Project Plan FY90

- SEES 3.0 System
  - Third side - Site staff
  - Insider Model
  - Prototype Sensor - Alarm Model
  - New Acquisition Model
- SEES Validation Plan
- Research - Conditional Planning

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The SEES project plan for 1990 is to develop and distribute the SEES 3.0 system of codes. For SEES 3.0, the following will be added.

The staff of a site can be a important factor if combat between a group of terrorists and the security force occurs. A third side in the simulation will be added to represent the site staff. They will be controllable with plans in the same manner as the other two sides. They can be hostile, neutral, or partisan to either the security force or the intruders.

In addition to the third side, active insiders will be added to the model. The active insiders may consist of more than one human, and can be masked as either part of the site staff or the security force.

Also the plans includes the development of a prototype sensor and alarm model. Various types of sensors, in varying combinations will be modeled. The alarm model will include the sensors in combinations and a logic method for an alarm such that the user can define the response required, and balance the rate of false alarms with the sensitivity of detection. Tamper alarms will also be modeled.

An important task for this year is the development of an overall validation plan for the complete model. The validation of the model will first be done on each modular process, and then for the entire integrated model.

Well, you might ask when is all this going to get done? The figure shows our plan for '89. Our current outside funding is not sufficient to carry out this plan, so the laboratory is going to pick up the difference because they are interested in seeing this happen. We should be able to complete a number of the essential editors this year, and we will start bringing them on line as they become available. We are going to have an algorithm editor that allows the user to vary the parameters of each and every algorithm in the model. There will be no data inside the model.

The SEES simulator is due in August of '89, and like I said, our research project for the year is the human acquisition model which we hope to have completed sometime in September.

In terms of planning for the future, we are going to develop an insider model. There will be people that work against the existing system where they bring in the wrong people, or the intruders bring in someone, or are able to bribe someone or coerce someone to open doors for them, or they get someone inside that can actually attack the PSOs and the site staff.

In summary, SEES is a versatile state of the art computer physical security model that allows many individuals to work the model in a team situation. SEES models the physics of events and is driven by measured field data. It has been tested and compared against field exercises, and is being developed with advanced software engineering methods.

In Summary

- SEES is a versatile state of the art Physical Security computer model.
- SEES allows many to work the model in a team situation allowing competition between sides.
- SEES models the physics of events driven by measured field data.
- SEES will be tested and compared against field exercises.
- SEES is being developed with advanced Software Engineering Methods
- SEES is being designed for a long extended life cycle.

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SEES is a computer model that provides a means for experts in physical security to evaluate and test the security of a site as well as train the personnel responsible for the protection of the site. The model is designed for those who are experts in neutralization tactics, and facility security design but novices with computer systems. SEES human - machine interface can be operated efficiently with only four days of practice, and all data files can be easily modified for the user's purpose.

A primary requirement of SEES is that the algorithms used in the model have a firm basis in physics, and are linked to the real world by measured field data. That is all parameters are obtained from actual performance tests, physical experiments, and field exercises. It is by formulation of the algorithms in terms of real world experience that we are sure of being able to validate the model.

SEES is being designed with advanced Software Engineering Methods that will make the model easy to maintain, modify, and document. We expect SEES to have a long extended life cycle lasting well into the 21 century.

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AFTERNOON SESSION
1:30 P.M.

MR. BANKS: I'll just share with you quickly some observations before we introduce the next speaker.

During lunch and just listening to some of the conversations in the hall, it appears to me that we have several groups in this audience. We have a group of people that are operations research oriented model builders. I also noted with some pleasure that we have several physicists, who have a lot of experience in modeling physical phenomena, and we also have a number of psychologists and physiologists who are very much involved in performance measurement–both from a behavioral point of view as well as a physiological perspective.

I think when you put those four or five groups of people together and you get them to focus on a common issue, the sparks begin to fly in terms of creative ideas and insights. This is one of the outcomes that we had hoped for. I didn't expect it until the second day, but I am starting to see little creative flashes here and there.

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The next speaker is Major Anderson from the United States Marine Corps, First Marine Division, who is one of the managers of the TWSEAS combat simulation system.

ADDRESS BY MAJOR WES ANDERSON, USMC

MAJOR ANDERSON: I am Major Wes Anderson. I am OIC at TWSEAS, Camp Pendleton. TWSEAS stands for Tactical Warfare Simulation Evaluation Analysis System, as shown in the first figure. This presentation is the same briefing I give a regimental commander who is not familiar with the system, does not know its capabilities or has ever used it; but it's been five, ten years ago since he played with the system.

The next figure provides the premise that we operate from. The closer we can come to simulating the real thing, then the better training that unit will have. When a unit wants to come out and set up a TWSEAS Command Post Exercise (CPX), first thing I do is find out what their objectives are. The system is designed to help unit commanders that want to improve their staffs'interaction so they make the correct tactical decisions at the appropriate time. In TWSEAS as in real life, if you make the wrong decision at the wrong time, you and your units are going to suffer for it. What is TWSEAS? It's just a computer aided command and control simulation system. We refer to our main frame as Leon, and Leon is basically just a large bookkeeper, and that's it.

Our objectives are to increase the realisms in the use of tactical exercise in terms of: relationships to cause and effect, timeliness, comprehensiveness, limitation of resources, impartial BDA, assessment, and authentic simulation. We do this by setting up a CPX landing force fighting an opposing force, and I'll get into that a little bit later.

The advantages of TWSEAS:

o You basically get to practice what you are learning. When the balloon goes up, hopefully you are able to apply the tactics, the techniques and the Marine Corps doctrine you have practiced in TWSEAS.

- The OPFOR tactics span the levels of engagement from the gorilla type environment all the way up to straight Soviet doctrine.

- Intelligence analysis in TWSEAS is phenomenal. The Intel officers or Intel sections are normally overwhelmed with the amount of information they receive, and they have a very tough time interpreting what they receive, analyzing it and aiding their commander to make the appropriate decision. There is more information than what they probably would receive in real life.

- TWSEAS allows commanders to practice their maneuvering and fire support for a particular TWSEAS exercise as a precursor to an actual field exercise. We have war gamed several exercise plans. We play the plan out and come up with different alternatives to it. The last time we did this was a precursor for a "Gallant Night" exercise.

o We present several different courses of action and the commander makes the ultimate decision as to which one he uses.

o We rehearse the exercise plans on the TWSEAS and let the commander try his OP plan before actual execution.

o Our primary emphasis is on exercising command staff and shaking down the command post organization. Some of the CP units that have come out and used TWSEAS, the commander says "time out," and we'll stop the system. He will reorganize things within his COC to make sure the right people are speaking to the right folks.

o A nice capability we have is the option of having a two-sided war, or force on force. We have not used this capability because the main emphasis has been on CP staff training.

I would like to make a few comments regarding our upgraded software called Integrated Maneuver Controller (IMC), which Mr. Lee Marsh of Systems Exploration, Inc., has been working on. In our current system (MMC) we have two-sided and replay capabilities. IMC will give us a three sided capability. Any questions regarding the three sided capability should be referred to Lee Marsh.

TWSEAS

Tactical **W**arfare **S**imulation **E**valuation **A**nalysis **S**ystem

PREMISE

THE CLOSER WE COME TO SIMULATING A REALISTIC BATTLEFIELD IN TRAINING...

THE BETTER WE CAN PREPARE FOR AN ACTUAL BATTLEFIELD IN WAR.

WHAT IS TWSEAS

TWSEAS IS A COMPUTER AIDED COMMAND AND CONTROL SIMULATION SYSTEM USED TO SUPPORT TACTICAL EXERCISE.

TWSEAS OBJECTIVE

INCREASE THE REALISM OF UNIT'S TACTICAL EXERCISE IN TERMS OF:

- RELATIONSHIPS TO CAUSE-EFFECT
- TIMELINESS
- COMPREHENSIVENESS
- LIMITATION OF RESOURCES
- IMPARTIAL BDA ASSESSMENT
- AUTHENTIC SIMULATION

TWSEAS ADVANTAGES

- PRACTICE/LEARN
  - TACTICS, TECHNIQUES AND DOCTRINE
  - OPFOR TACTICS, TECHNIQUES, AND DOCTRINE
  - INTELLIGENCE ANALYSIS
  - MANEUVER AND FIRE SUPPORT PLAN FOR FIELD EXERCISES
- WARGAME EXERCISE PLANS
- REHEARSE EXERCISE PLANS
- SHAKEDOWN CP ORGANIZATION
- TWO-SIDED AND REPLAY CAPABILITIES

The current MMC system gives us up to 256 addressable units. Those units can go from a single man unit up to a full blown battalion unit with associated equipment, or a regiment unit if necessary. One of the upgrades in IMC will give us 600 addressable units, and at the same time allow us to have four exercises going on simultaneously. This means we will have increased the number of units up to a maximum of 2400.

With our current exercise environment the terrain is digitized on a game board covering 1200 km by 1200 km, and within that area we operate with 100 kilometer digitized square. The resolution goes down to 500 meters. The things we take into consideration are elevation, traffic activity; and that's for foot, wheeled or track vehicles and the vegetation. We also handle weather and time of day.

With the IMC upgrade we will still have a 1200 by 1200 kilometers square, but within that area we will have 25 separate areas of 100 km by 100 km and that will be digitized, and the resolution will be variable at our option from 500 meters down to 100 meters. The time of day and weather in the present system can go from clear, all the way up to snow. The sun rises and sets as I dictate, which is nice.

Some of the ground combat capabilities within the TWSEAS system are listed below. Over the years the enhancements have made it a very comprehensive and detailed model.

<u>Movement</u>. During training exercises your movement cross country is in real time. If a unit is walking from point A to point B, and the distance is four kilometers and they are traveling on a road at four clicks an hour, then it will take them one hour game time, or one hour of real time to cover that distance.

<u>Detection</u>. The model includes line of sight detections, so if you see the opposing force, they will show up on your monitor. The detections are predicated upon the digitized terrain, troop posture, i.e., is he dug in and hard to see, and the size of his unit. All these things are taken into consideration.

<u>Engagements</u>. We instruct commanders to tell their units which way to face, what formation to be in, what type of frontage they want them on, and to give them a sector of fire; the same type of information they would give a basic Marine Corps private, a rifleman. If they do not do that and the opposing

force gives those orders to their particular units, the opposing forces are going to win.

Casualty assessment. It's predicated on what we decide. Stochastic effects are used for several smart weapons, while single shot probability of kill is used for more conventional weapons.

LIDS. The system currently has the capability of LIDS, night vision goggles, and night intense finding devices.

NATO vs NATO Capability. On a force-on-force exercise, we can take both OPFOR weaponry, put it in landing force units or NATO weaponry, and put it in OPFOR units.

Barriers. We can simulate barriers of everything from a mine field to a sensor field to a tank ditch.

Another aspect of the ground combat is surface fire support. We have naval gun fire and they will fire with the appropriate naval guns or anti-aircraft weapons. We can also call in artillery support, the entire gamut of artillery weaponry that is available to the Marine Corps forces; mortars; 61 mortars, 81 mortars, and on the opposing force's side 122's and 82's. We can shoot smoke. If you shoot smoke it decreases your line of sight detections. It will not slow down your rates of movement, but it can hide you and conceal you as necessary. When the sun sets, it does get dark within the system and your detection range decreases appropriately. If you shoot illumination you can get up to 80% of a daylight detection, which is basically realistic. If you want to shoot a dual purpose conventional improved munition, you can. If you want to shoot an ATDC fuse, you can. We have a combination of shell fuse options.

On the air side, TWSEAS does have the air-to-air war and airborne early warning capability. We can put up an AWAX to detect OPFOR aircraft coming in, and they can do the same thing. You can call in fighter support and cap a section to protect the particular area you are fighting in. The aircraft in your caps will engage OPFOR aircraft and the OPFOR aircraft will do the same thing. The damage assessment that goes along with it is predicated upon the weaponry that the aircraft are carrying.

MMC CAPABILITIES

SURFACE FIRE SUPPORT

- NAVAL GUN FIRE
- ARTILLERY
- MORTAR
- DAMAGE ASSESSMENT
- SMOKE
- ILLUMINATION
- ROUND/FUZE SELECTION

MMC CAPABILITIES

AIR-TO-AIR

- o AIRBORNE EARLY WARNING
- o FIGHTER SUPPORT
- o DAMAGE ASSESSMENT

MMC CAPABILITIES

GROUND COMBAT

- MOVFMENT
  (CROSS COUNTRY AND ROAD)
- DETECTION
- ENGAGEMENT
- CASUALTY ASSESSMENT
- LIDS
- NATO VS NATO CAPABILITY
- BARRIERS

TWSEAS has the capability of flying deep air-to-ground missions to provide close air support of the ground forces. Damage assessment is provided both for the air to ground and for the surface fire support as in real life. If you call in supporting arms very close to your position or on top of your position, you will take friendly casualties. That comes as a hell of a shock to a lot of commanders, and they can't believe that some of their troops were killed within the quasi system just because they called an air strike on their position.

Anti-Air. TWSEAS can simulate SAMS, AAA, ground based radar for early warning detection, fighter air to air support, airborne early warning, and TAOC.

Intelligence, the current system will accept ground reconnaissance, as in a recon team sitting out there and sending their reports back. We can also get intel from unattended ground sensors, or aerial reconnaissance missions, both photo and visual. The new TWSEAS system will add an infrared (IR) capability, and a remotely piloted vehicle (RPV) simulation. All of these intel systems provide real time information.

Combat Service Support. Within TWSEAS we track ammunition, vehicles by type, personnel, number of medevacs, a supply dump, and convoys. All those things are taken into consideration.

What makes TWSEAS unique is that we do the ship-to-shore movement. We basically take a unit's landing plan, we code it up, and they do the surface landing scheduled on call. We have the capability of damaging landing craft, both surface and helicopters, as a part of the ship to shore movement. We don't really evaluate the landing plan, but we can indicate to a unit where they might have a weak spot in their plan. For instance, they may want to load up more material in a Mike 6 landing craft than it will hold. We point out these problem areas.

Since I have been at TWSEAS, I have conducted over 60 command post exercises, the largest one being Marine Corps Division (MEF) level. That's a very time consuming and very intricate operation. On the aviation side, I have had a Marine Corps air wing come down, and a couple of different Marine Corps air groups as part of a Marine Corps expedition and brigade. One of the nicest things about the present TWSEAS set-up, that's due in part to my boss, the Commanding General of the MEF, is that TWSEAS is (1) not required by any using unit on base, and (2) there is no evaluation or report card. So units have the opportunity to come out to TWSEAS and try their unit

MMC CAPABILITIES

AIR-TO-GROUND

- DEEP AIR
- CLOSE AIR SUPPORT
- DAMAGE ASSESSMENT
- RADAR AND AIR DEFENSE SUPPRESSION

MMC CAPABILITIES

ANTI-AIR

- SAM & AAA
- GROUND RADAR
- FIGHTER AIR-TO-AIR
- AIRBORNE EARLY WARNING
- TAOC PLAY

MMC CAPABILITIES

INTELLIGENCE

- GROUND RECONNAISSANCE
- UNATTENDED SENSORS
- AERIAL RECONNAISSANCE
- RPV SIMULATION

MMC CAPABILITIES

<u>COMBAT SERVICE SUPPCRT</u>

- WEAPONS SYSTEM
- AMMUNITION
- VEHICLES
- PERSONNEL
- MEDEVACS
- DUMPS
- CONVOYS
- BARRIERS

MMC CAPABILITIES

EXERCISE ENVIRONMENT

- TERRAIN
  - ELEVATION
  - TRAFFICABILITY
  - VEGETATION
- WEATHER
- TIME OF DAY

SOPs with no incrimination. If they work, that's super; if they don't work, they can go back home and revise their plan.

TWSEAS definitely simulates the decision execution. If a decision to take a hill is made, and they fail to take into account what is located on that hill (they have not used the proper fire support and coordination necessary to get that hill), they lose a company in the process of taking it. Historically units that have come out to TWSEAS ready to fight their war assume they are going to fight against the computer, which is not so. They fight against my intel officer and his assistants. My intel officer fights whatever opposing force scenario that the unit has requested.

Units that come out to use TWSEAS go through three separate distinct phases. First one is "Oh, my god, what is that computer going to do to me?" They are very much afraid of it. After they go through that phase, they decide that the TWSEAS complex is a very large expensive Atari game, and they are going to win the game no matter what it takes. And the last and best phase is, when they decide they are going to utilize the tactics they have been taught, to utilize the fire support the way it's supposed to be, and fight the war, they really would.

TWSEAS is currently being run on an AN/UYK-7 computer. It is an antiquated machine, but very reliable. It's old, it's semi-slow, but it works. With the latest hardware upgrade that I received a month ago I now have the capability of going out and doing remote exercises via a modem. Future upgrades include the procurement of a fourth unit that will be located in Okinawa.

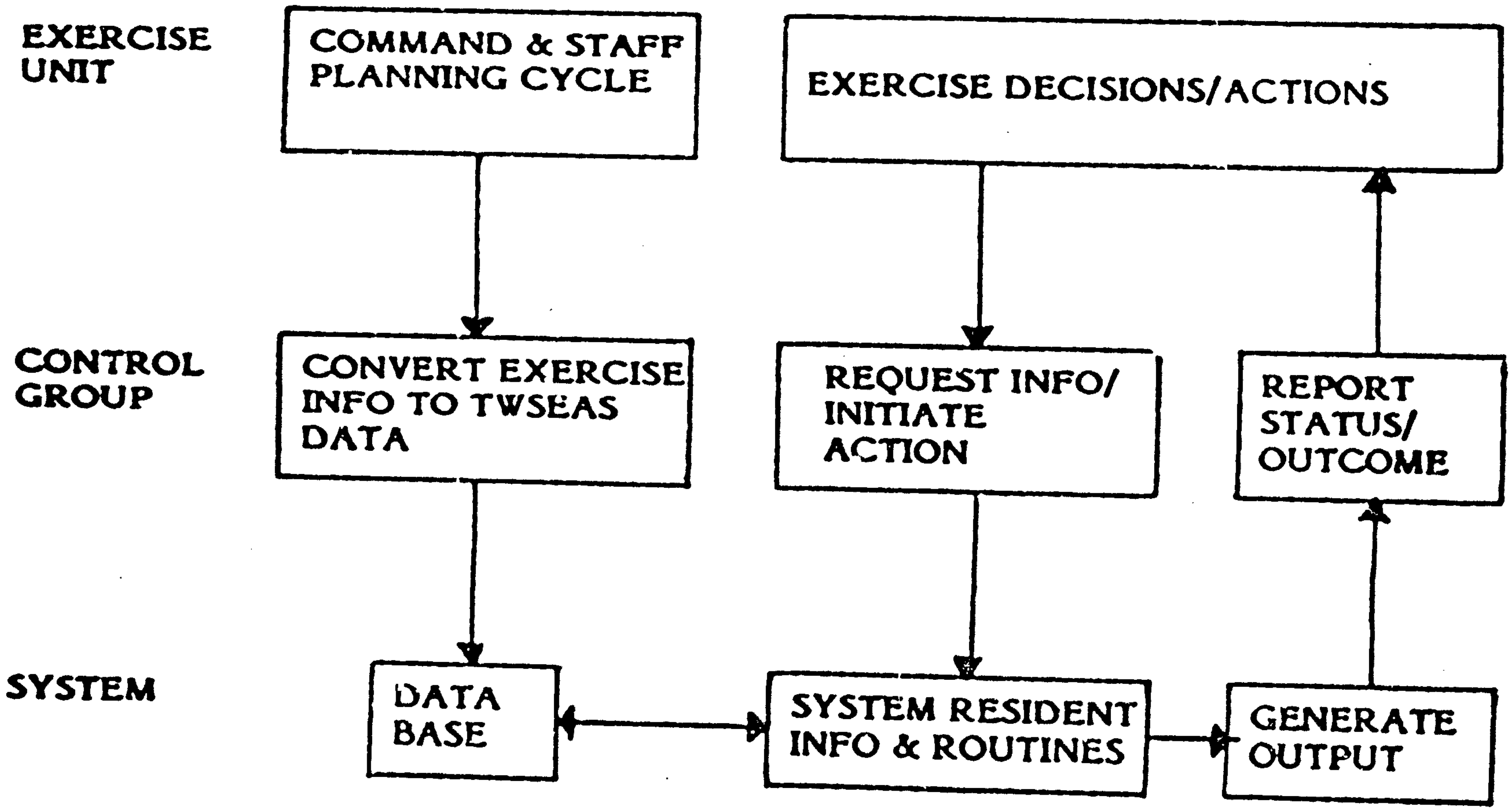
One thing that TWSEAS under the present software configuration does not do, is simulate human factors. The electrons never get tired, they'll fight 24 hours a day, they'll march forever, and do whatever you dictate. Lee Marsh, at System Exploration, Inc., is setting up a module that will take some human factors into consideration. The new system is going to be table processor driven, which will provide us with a lot of flexibility to edit the tables as necessary.

MMC CAPABILITIES

SHIP-TO-SHORE

- SURFACE LANDING (SCHEDULED AND ONCALL)
- HELIBORNE LANDINGS
- OPTIONAL DAMAGE ASSESSMENT
- LANDING PLAN TESTS

CONDUCT OF EXERCISE



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No. 1

US ARMY
MATERIEL
COMMAND
BALLISTIC RESEARCH LABORATORY

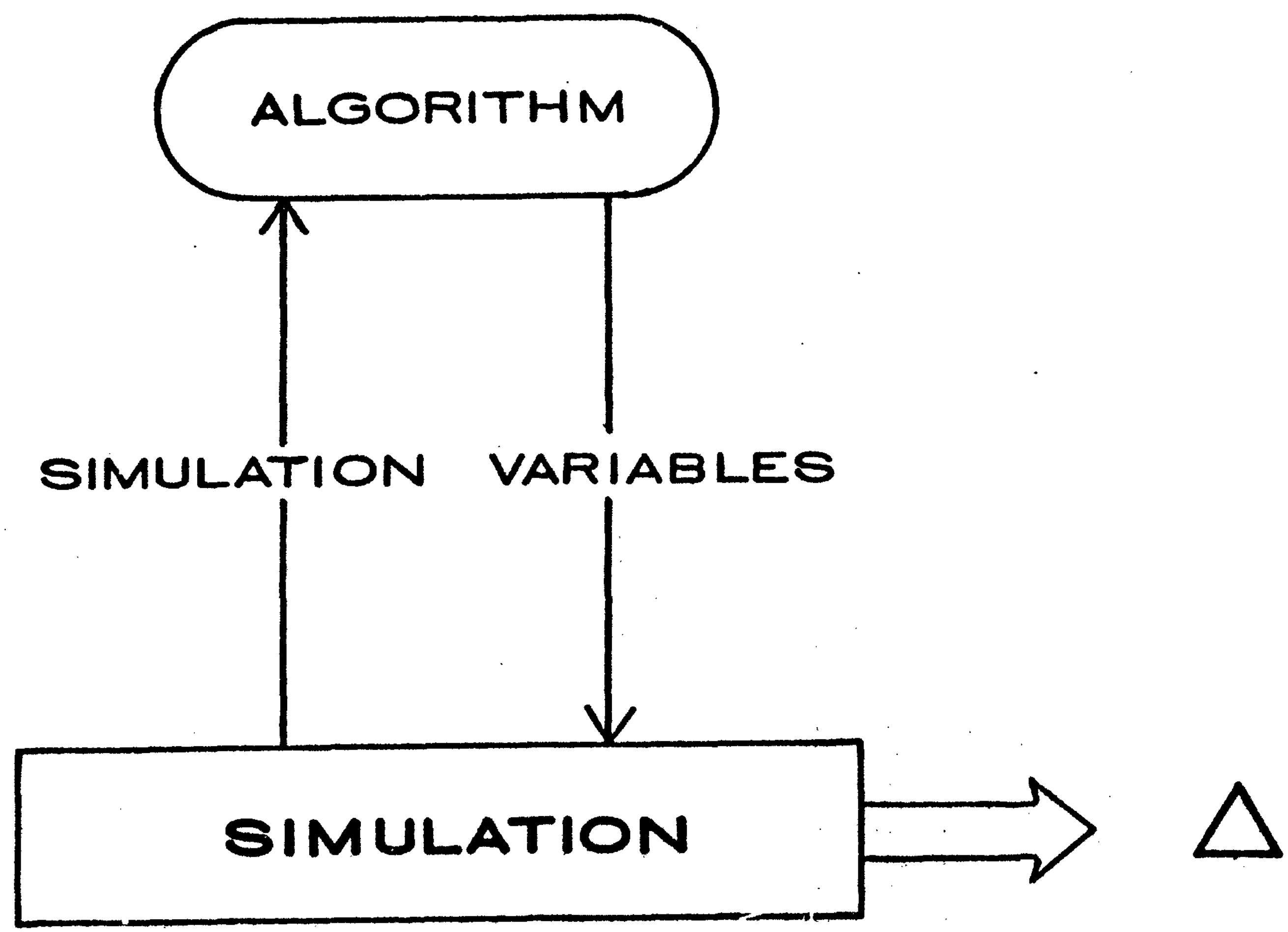
ARMY UNIT RESILIENCY ANALYSIS (AURA)

Dr. J. TERRENCE KLOPCIC

US ARMY BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MD

AUG 85

AMC · Providing Leaders the Decisive Edge


ALGORITHM
SIMULATION
VARIABLES
SIMULATION

ADDRESS BY DR. J. TERRENCE KLOPCIC

DR. KLOPCIC: The purpose of this conference, as I understand it, is to match human performance people with modeling people. First of all, I don't think human performance models are that much different than physical performance models. It takes three things to simulate human performance or any technical phenomena. First, you have to have some sort of algorithm, or data base, or functional fit that is going to describe the human performance parameters we are talking about. Clearly here it's been things like fatigue or locomotion speed, or whatever. It also takes a match between the simulation and the algorithm. The algorithm is going to take some kind of inputs. We just heard about snow and cliffs that go up at 90°, etc., those are inputs--(a) they have to be generated by the simulation, and (b) they have to affect the algorithm. That's the second thing. What you have to have is an interface. The outputs of the algorithm are going to be variables. These variables have to have a place in the simulation, and they have to have some sort of a change; they have to cause some sort of change in the output. Clearly this is motherhood, and is what we have all been saying right along.

What I want to do is try to organize my talk on AURA (Army Unit Resiliency Analysis) based on these three things, the algorithms--how they go in, how they come out, and the difference they make. I think if I can get that idea across, then each of us in his own little portion, be he a human factors type or a modeler type, can see how the various parts will interact with his job.

With this framework in mind, I am going to start my talk with a discussion of the simulation portion, because things will make a little more sense if I do that. I will start with AURA, then I will go through a couple of the human factors models. I am under the impression that we are primarily interested here in human factors and human performance. So with the exception of heat stress, which is really a casualty producer, I have left out the casualty producers in AURA. I haven't gone through the chemical and nuclear effects at all, but rather I will concentrate on those things that degrade human performance.

I want to show you by describing AURA, how these things affect the output of AURA, and then I'll describe some of the algorithms. AURA stands for the Army Unit Resiliency Analysis. Resiliency is the ability of a military unit to perform its mission over time, including times following hostile attack. The purpose of AURA is to describe the functioning of a unit. Functioning despite insults caused by hostile attack. AURA is the state of the art methodology for analysis of the unit to determine what has happened to its functioning capability. Although what happens to the individuals is clearly important, it is not the end goal. The end goal of AURA is to lump the individual affects together to show what happens to the functioning of the military unit.

"Unit" here refers to rather small groups. We use AURA for company, battery, sometimes battalion, but you will see at the level of technical detail that gets built into AURA, it would start to get a bit tedious if one went much over a battalion size unit. An important factor in this discussion is what do I mean by the functioning of a unit? We need to describe the functioning with a measure of effectiveness. I like to think of measures of effectiveness as falling into two different types. One measure of effectiveness might be something like a rate or a quality; something that is predefinable.

For example, an ammunition company should be able to receive and warehouse 2200 short tons of material a day in a field unit. That's a rate or quality type measure of effectiveness. I will judge the unit on its ability to do 2200 short tons. It's predefinable. I have just defined it. Other examples are rounds per minute, trucks loaded per day, correct messages per hour, etc.. This type of measured effectiveness is most appropriate for a one-sided analysis, a one-sided unit. An ammunition company is a good example of a unit that would be analyzed in a one-sided analysis. "One-sided" means that blue cannot protect himself by shooting red first in the game. A priority, the attack against blue is predetermined. That makes it a one-sided analysis. Blue can try to protect himself by taking evasive measures, but he cannot change the incoming. There is no inter-reaction on the incoming.

On the other hand, most of what we have heard so far today, certainly Janus and SEES and the rest of these models, are what I would call the battle time type measures of effectiveness. They are complex and indirect, such things as FEBA movement, loss ratios, and momentum type criteria, i.e., "did you take that hill?" These are really a two-sided type measure of effectiveness, and it requires a two-sided game.

AURA is a one-sided game, therefore, the units that we use AURA for are units like Army combat support, combat service support units. You would not use it for a tank battalion engaged in combat, because you are more interested in who can hide behind a hill; which does not play in AURA. On the other hand, ammunition companies don't hide behind hills. Rather, what's important is how much can it take and what can it recoup. What can it do to modify the effects of the damage in order to get down to doing its job? What happens to its rate of performance after an attack? What this says is that AURA fits in a different place in the hierarchy of war games. The next figure shows some of the war games from the Army model improvement program.

You will notice in this little diagram that there is, along with the size of a unit, an intrinsic time period that is appropriate for an analysis of a unit. Companies (even battalions) will fight on the order of hours. If you start coming up to divisions or corps, you start looking at analyses that will run days, maybe into weeks. Theaters, maybe more.

Notice that the time frame that is appropriate for a combat company does not hold for a support company. For an ammunition company, it's more appropriate to be looking at what it's going to be able to do over days, because that ammunition company will be working in isolation for days. So is a ship, probably. These support units are best described by AURA and resiliency. So AURA is not an alternative to something like Janus. Actually, AURA is a compliment to Janus, CORBAM, CORDIVEM, VIK, or any of the two-sided war games. AURA is in a position to feed the war game models information from combat service and combat support units.

Enough about where it fits. As I said, the purpose of AURA is to provide a means of evaluating in detail the effectiveness of combat against the performance of a unit, against the output of a combat unit, or of a support unit, or a combat unit in reserve.

Another purpose, a methodological purpose in our building AURA, was to amalgamate in one place the accepted state-of-the-art methodologies. In developing AURA, the Ballistic Research Laboratory really did not so much develop a new model as it did put together in a framework a number of models that already existed, that had been developed by the lead laboratories in the various areas. There are places to go if you want conventional vulnerability data, or if you want nuclear effects. There are places to go to get them. What we did in producing AURA was to develop a framework to tie these models in to show what happens to one-sided units. As a result, we refer to AURA as a family of methodologies. There is a code called AURA. Tied into AURA are conventional, nuclear, toxic chemical, MOPP degradation, nuclear doses, and the data from IDP. AURA also includes information on unit organization, what jobs they do, how they deploy, what weapons would be used against them, how they repair, etc., etc..

DEGRADATION

DECREASE IN SUBJECTS' PERFORMANCE AS GAUGED BY VARIOUS MEASURES OF EFFECTIVENESS (MOE)

MOEs

RATE/QUALITY	*"BATTLE"*
PRE-DEFINABLE	COMPLEX, INDIRECT
e.g. ROUNDS/min	e.g. FEBA MOVEMENT
TRUCKS LOADED/day	LOSS RATIO
CORRECT MESSAGES/hr	"MOMENTUM"
(ONE-SIDED)	(TWO-SIDED)

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Each of the boxes in the next figure represents at least one (and in several cases many) different agencies that have produced the models that they use at the technical level. Those models were taken pretty much intact and swallowed up into the AURA.

The AURA code itself is a one-sided event simulation. After processing the inputs, the code steps from event to event. If the event is a lethal event, i.e., some rounds coming in, the model pops over and grabs the appropriate algorithms for analyzing the attack. If it is a chemical attack, it starts laying chemical grids on; if it's a nuclear attack, it runs through a series of DNA environment calculators; if it's a conventional attack, you use the routines that were referred to earlier to calculate the effects. It then pops down and goes to the next event.

The next event is what I call a reconstitution; a time at which the smoke is cleared and the commander can try to get his act back together. He can try to see how well his unit performs. AURA then runs through a series of steps.

First, it updates the time dependent factors. There are a great number of time dependent effects such as the progress of fatigue (which you have heard so much about here), or the progress of nuclear doses, which I'll show. The code updates the time dependent factors and out of this it comes up with a set of degraded assets, a pool of degraded assets for the commander to use.

It then pops into the allocation model which models the smart commander. The smart commander takes a look at the assets he has, the job that he has to do, and he allocates those assets in such a way as to optimize the performance of his unit to try to get maximum output. It accumulates the statistics and makes any changes that the decision maker has caused. For example, if people get assigned to new jobs, they get redeployed. At this point the model pops back into the event and continues on with the battle.

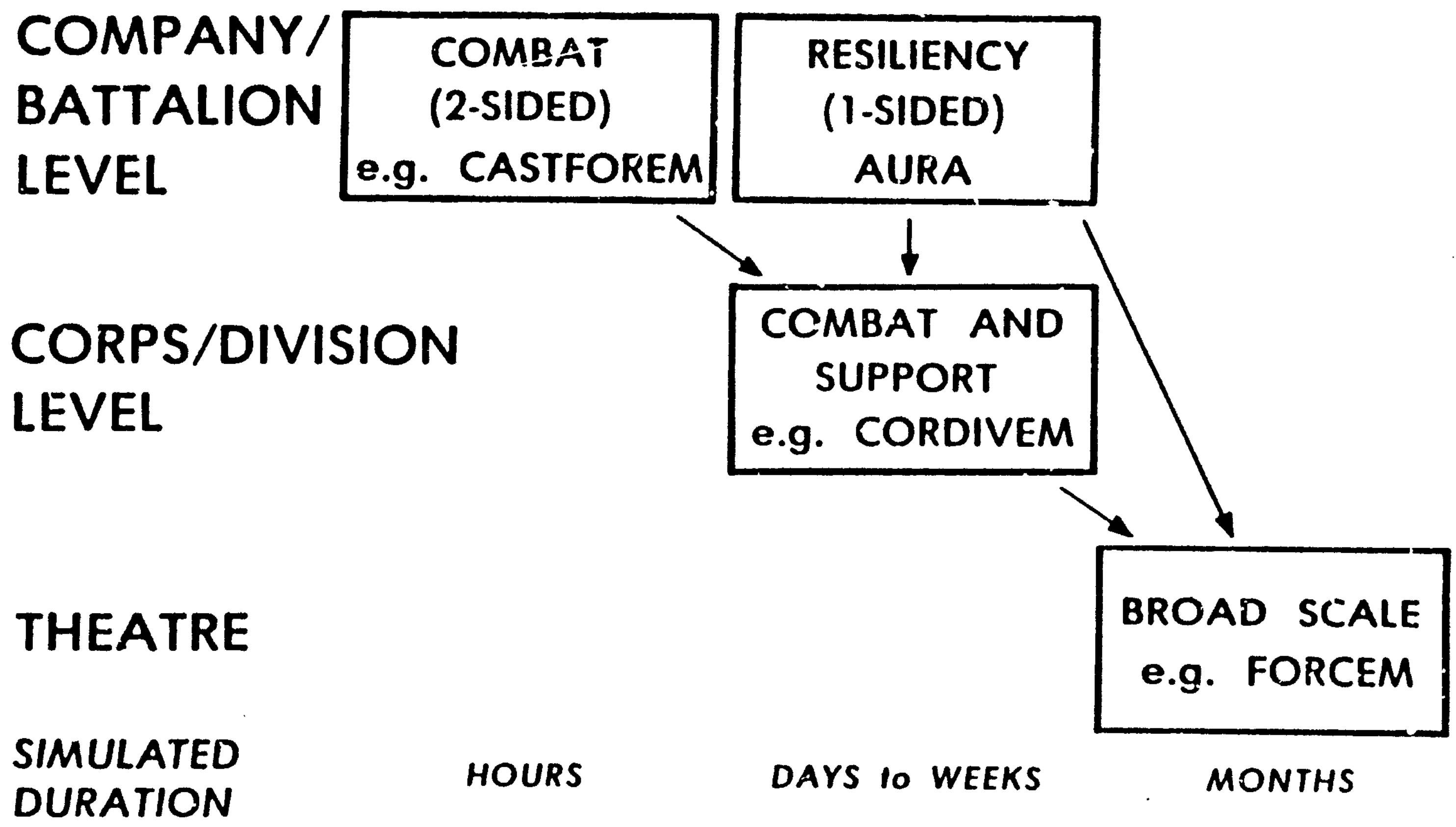
The model runs on a number of different machines, and in about 12 or 14 different agencies including a couple overseas. We run the model on Crays, we are really spoiled. But it runs on Univac, it runs on VAXs, and it runs in places like Track, Wizmer and White Vans.

I put this next figure in because I wanted to remind myself to talk about assets. A very important concept in AURA is to separate your definitions between assets and jobs. I have referred to assets as physical things, such as people and equipment that are in a unit. Assets, for example, are the kinds of things you see in the figure. They are deployed. Assets are the things that you can count. On the other hand, each of the assets has some sort of capability that the commander can apply to doing a job. Somebody operates the radio. It need not be the guy whose MOS is radio operator, but if I am a commander and I have to assign somebody else in that slot, I am going to take a degradation. There is a human factor. The human factor is the bridge between the assets which are the things that you have and the jobs that they can do. You apply the human factors to the assets and you come up with how much good can they do for your unit. I'll try to really make this concept clear because it's really one of the things that has made AURA easy to apply human factors to.

It's also important that I describe how AURA evaluates jobs, how AURA evaluates the mission, and the steps in describing a unit function. First, one has to quantify the mission. You notice in the beginning when I talked about measures of effectiveness, I came up with a very quantitative measure of effectiveness. It is number of rounds that are loaded per hour or fired per hour, number of trucks that are loaded, or something that I can count. It's important to quantify the mission, because after quantifying the mission, I am going to go through and describe exactly what kinds of jobs, what kind of functions have to be accomplished, in order to get that mission done at the level that I quantified it.

Here is an example of a simple flow diagram. This is a unit that has to load trucks. In particular this unit receives instructions from someplace telling it what to put on the trucks. It receives the instructions either by radio or telephone, the way my unit is set up. On the average, 75% of the items that I am going to load on the trucks can be loaded by a forklift and a forklift operator, they are fairly light items, or if push came to shove, I could hand load them, but that's not quite the way to do it. The other 25% of the items to be loaded are heavy items, I have to use a crane, operator and rigger. I have to have trucks and drivers. It's nice to have a loadmaster to kind of get these guys along, although we can also describe this as a nice-to-have job; that is, there is some intrinsic managerial capability in the outfit, the outfit will still load trucks if the loadmaster isn't there, but he is nice to have. This is what I meant by a flow diagram. This is the way that AURA thinks about doing a job. Each of these jobs has to be done.

AURA
IN THE HIERARCHY OF WARGAMES



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No. 5

AURA

A MEANS OF EVALUATING, IN DETAIL, THE EFFECTIVENESS / RESILIENCY OF ARMY UNITS, FACTORS CONSIDERED INCLUDE:

- THREAT WEAPONS
- PERSONNEL AND MATERIEL
- FUNCTIONAL STRUCTURE
- TRAINING AND DOCTRINE
- TACTICS
- SCENARIO

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AURA

PURPOSE-METHODOLOGY

- TO AMALGAMATE, IN ONE PLACE, THE ACCEPTED STATE-OF-THE-ART METHODOLOGIES
- TO APPLY THESE METHODOLOGIES COLLECTIVELY ALLOWING ACCURATE INTERPLAY OF DIVERSE FACTORS

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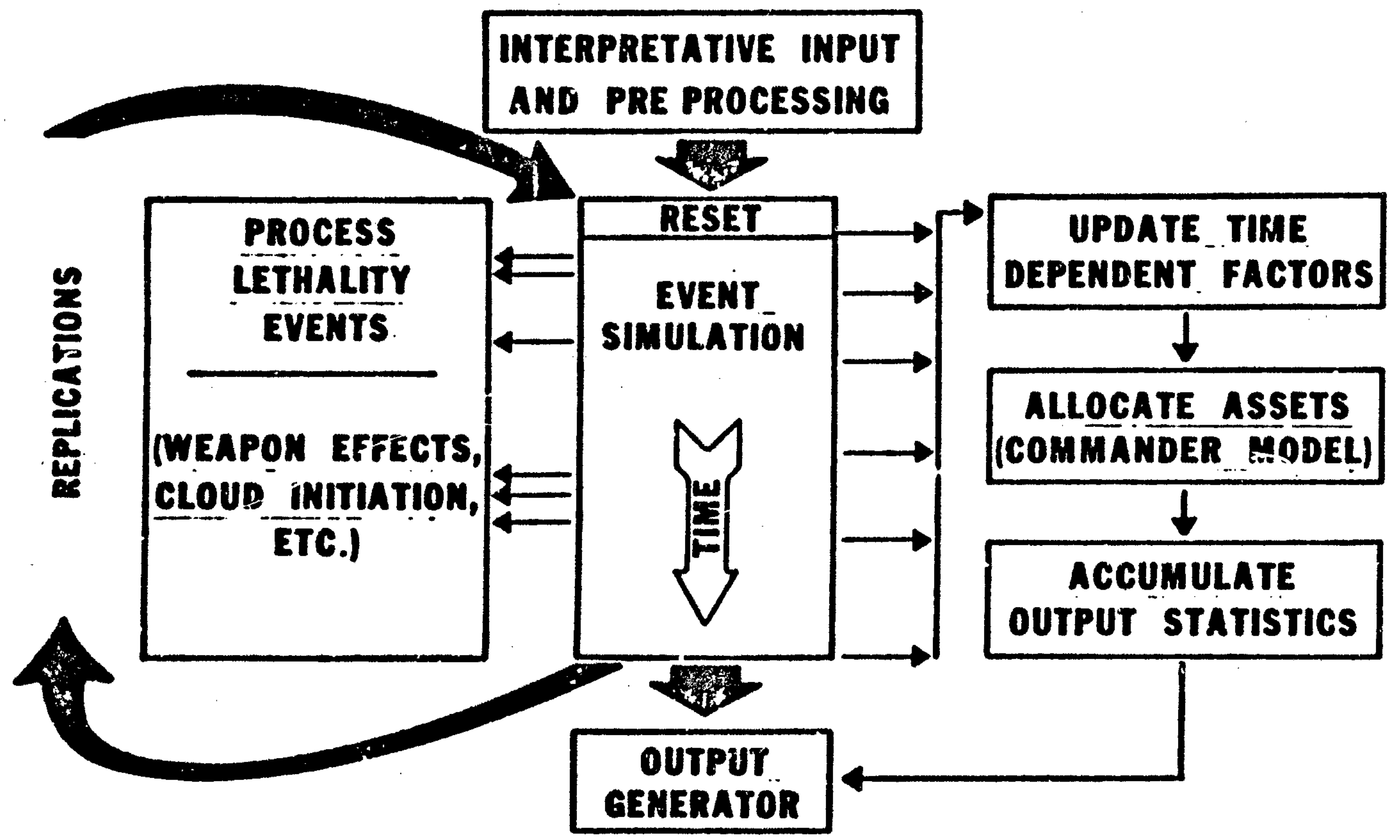
AURA CODE FLOWCHART



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The guys that come in here and hand load can have any MOS. They just need to be able to get the job done.

This is the way AURA's commander thinks about doing his job too. AURA's commander also has the following thought. "Suppose that my job were to load ten trucks per hour, and I only have seven trucks per hour available, and my semi-deaf radio telephone operator can only take five messages per hour?" I will load five trucks per hour. The ability of this unit is dictated by the choke point in the flow diagram. Commanders all engage in choke point analysis. When commanders go about assigning their assets after being attacked, they start assigning assets preferentially to the choke points. That's the way they are trained to do their job assignments. Commanders and AURA have gotten a little smarter over the years. They know enough to save their most versatile people. They know enough to worry about the hard-to-fill jobs. But in the final analysis the commander is going to take his assets, apply them to the jobs, and at some point he is going to get stuck. At that point, we have determined the effectiveness of the unit. The effectiveness will be dictated by the choke point; the ability of the unit to do its job. Notice (incidentally) in the process of describing this flow, I have alluded to quite a few different mathematical relationships between the things.

The next figure presents some of the various relationships that are found in AURA.

There are, besides the "and," and the "or's," the other relationships available in AURA. It's the ability to link and combine these various things that have allowed AURA to be a fairly flexible kind of system. Pretty much things are going to be "and's," "and/or's" or "sums of things," or combinations of "and," "and/or's" and "sums of things."

I just point out we have done a number of systems that have been really quite complex, including an aviation maintenance company that had something like 240 or 250 different jobs. Interesting kind of company, because there are so many specialists in it. There is a lot of covering up within some specialties, but certain weak links that really would come out in a group like that. In describing AURA, I have talked about the unit AURA as a whole and what it's doing. It's moving through a day and taking its lumps and then trying to reallocate its assets. The commander is going to worry about the hardest filled jobs and all that sort of thing.

The thing I haven't shown about AURA is the relationship between the assets and the jobs. That relationship in its most general form is described by what I call here a link effectiveness curve. Basically, it says that with no assets at all I might have some capability. Beyond some threshold there should be an increased ability to do a job as I put assets in up to some optimum and beyond that it doesn't help to put any more in. This is the most general form of link effectiveness curve. Most jobs (if you don't know much else about them) get models like this.

There are jobs, however, like the loadmaster, where the system continues to function, even with the elimination of the position. Without a loadmaster there is still some intrinsic system capability. Handloaders (on the other hand) have a threshold. You need a couple of them or you can't lift a pallet; therefore there is a threshold.

It's important to note that what we are talking about is the abscissa of the Link Effectiveness Curve, the effective allocation of assets. Here is where the human factors come in. Because if I have a man who is at half capability because he has taken a whiff of nerve gas, or because he is wearing MOPP gear, (what I mean by half capability is that when I put him in a job, he will do half as well) he would be half as much of a contributor to the job as he would if he were a whole man. So this is clearly the obvious place to put in human factors. Human factors do not affect the unit. Human factors affect the ability of the asset to do the job. Then it's up to the commander to use those assets as well as he can to try to optimize the ability of the unit to work. So my human factors are going to come in on the abscissa of the Effectiveness Curve. They are going to degrade the assets the commander has when he goes to assign them to doing jobs.

To summarize AURA, there are assets that have physical characteristics so they can be deployed, and they are vulnerable to weapon effects that can be used against them. These assets can be degraded because of what happens to them. The degraded assets or effective assets can be applied to a job. Depending on how well this job and all the other jobs can be done, and how well my smart commander allocates his assets determines the success of the mission.

The next diagram describes the AURA functional structure.

STEPS IN DESCRIBING UNIT FUNCTION

- SPECIFY, QUANTIFY MISSION (S)
- DRAW FLOW DIAGRAM
- DESCRIBE SUBTASKS
  - SUBTASK ACCOMPLISHMENT vs ASSETS
  - ALLOCATABLE ASSETS

AUG 85

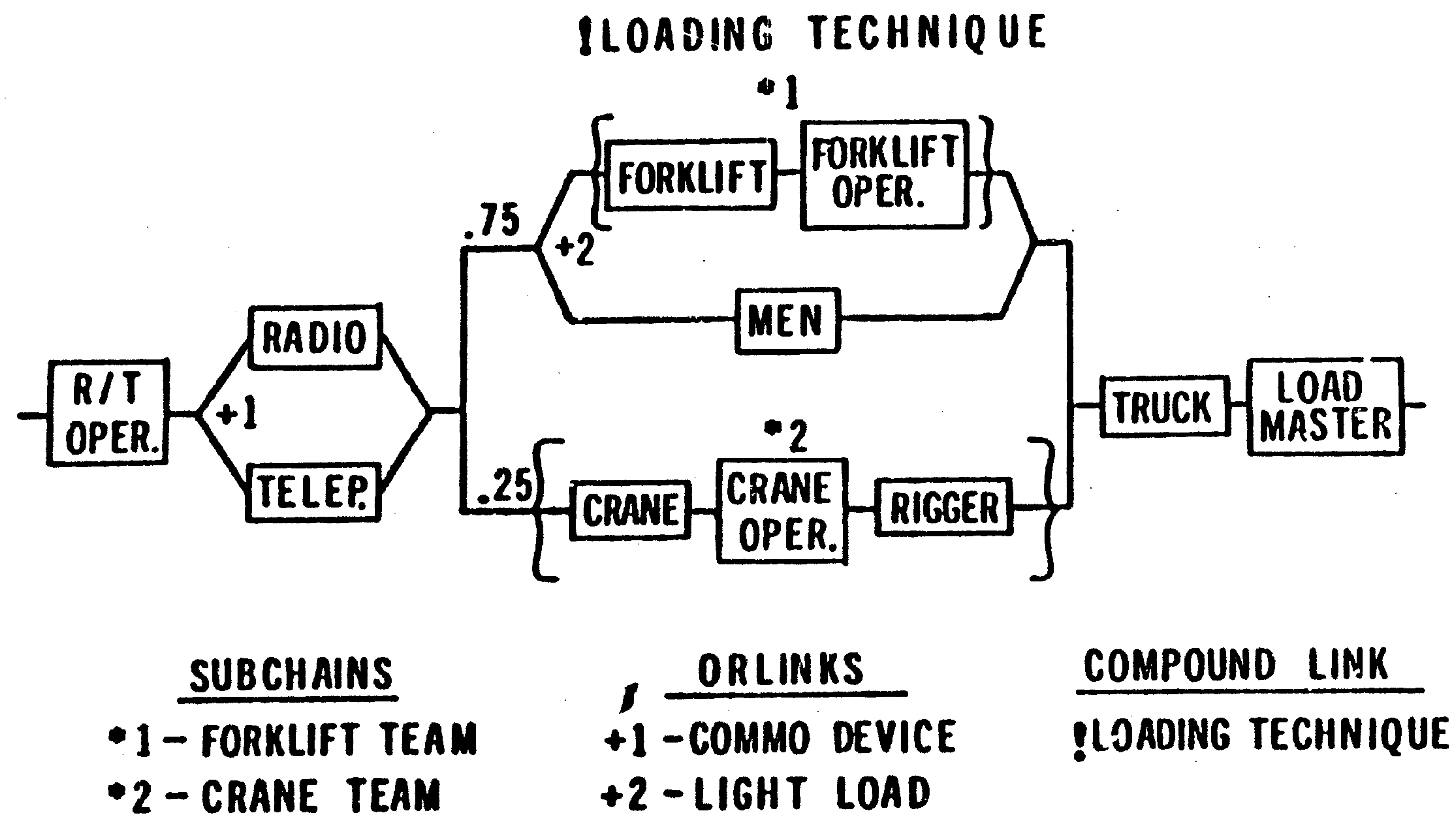


Figure 5. CHAIN for the Example Unit

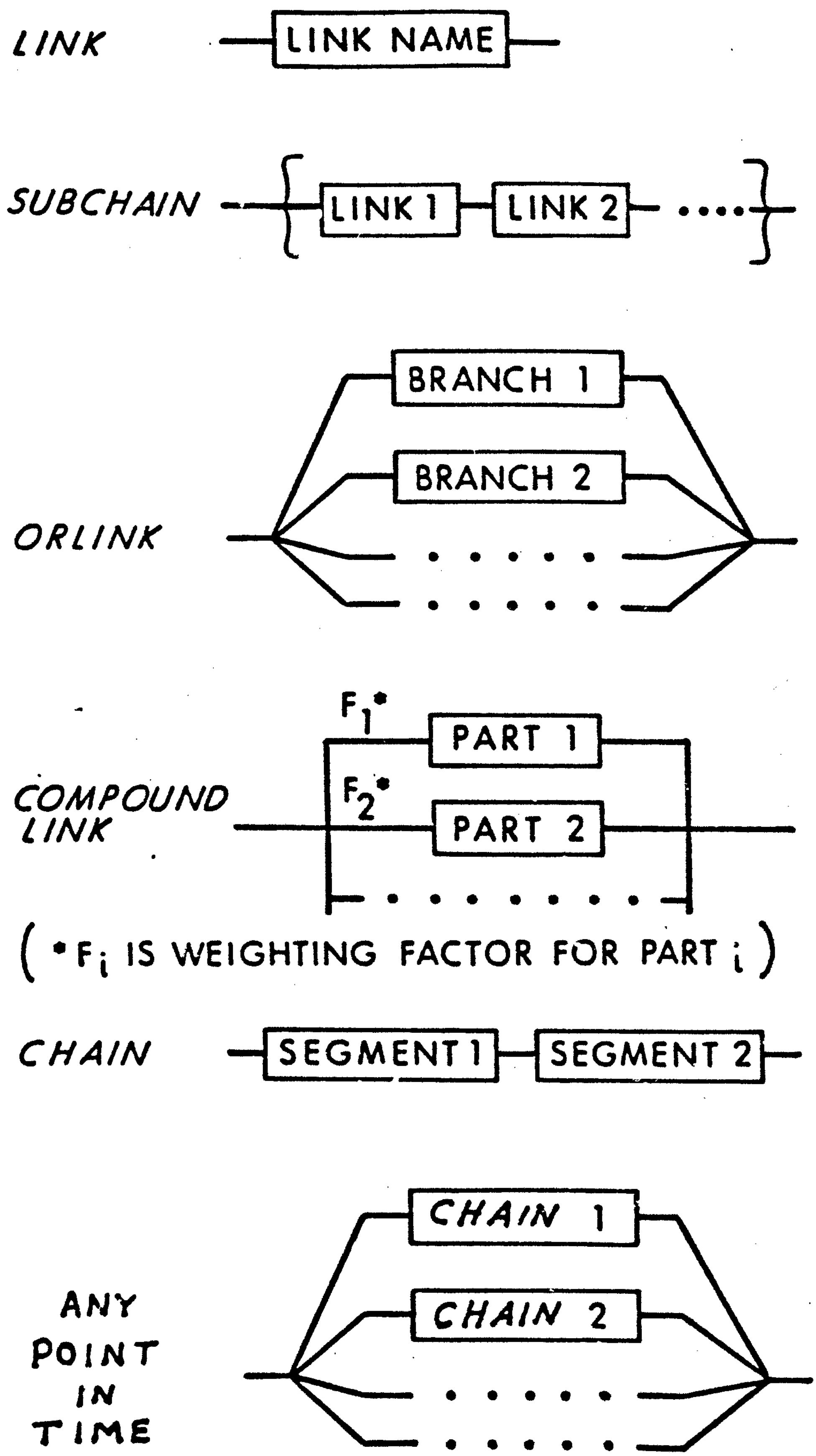
There are three parts, and each has its own algorithm. The algorithms use inputs that come from the weapon effects, and the outputs indicate how well the individuals can do their jobs. The smart commander optimizes that to make the unit work.

The AURA outputs as shown in the next figure indicate how well the units can do their job. They provide information on personnel losses, task performance, etc. That's AURA in a nutshell.

Let me continue by briefly giving you a few of the human factors models that are currently running in AURA; effectiveness of substitutes, sublethal doses, etc.. There is always a trade-off between accuracy and rate. I think almost on any job you can find, you can speed up if you are willing to give up accuracy up to a limit, and up to a limit you can slow down and do a little better job.

It is assumed in the way we train troops, in the way everything is done, that there is a minimum standard of performance (shown by the dashed line in the next figure), and that the troops will perform to that level. They will perform to that level, even if it takes them more time. The man on the normal curve (the "N" in the figure indicates the normal curve), is undergraded, and he can trade off accuracy for rate, as long as he operates someplace above the dashed line. He is going to operate above the dashed line, because he has to have that level of accuracy to pass his job. The accuracy level dictates the rate at which the normal troop is going to operate. Of course, there are standard deviations, but we can define an accuracy and a rate at which that guy is going to operate. When he is degraded he still has the trade-off possibility. We again assume (and based on everything that we have seen so far it's a good assumption), that he will still try to do his job correctly. He is not going to put the round in backwards, he is not going to call somebody else instead of the call he is supposed to make; he is going to keep trying until he does his job correctly, and therefore, he is going to attempt to operate on or above the dashed line. The degradation therefore comes in a altered rate of performance.

It's important to have a grasp of this concept when one is defining the mission blocks that we have. If I say an individual can load 2200 short tons per day, and the guy now has radiation sickness, he is not going to put the wrong thing on the trucks, he is going to slow down. I don't have to worry about quantifying the effect of putting the wrong thing on the truck, but what I do have to quantify is what happens when he is sick and he is not loading as a rapidly as he did.


LINK
LINK NAME
SUBCHAIN
LINK 1
LINK 2
....
BRANCH 1
BRANCH 2
ORLINK
F1*
PART 1
COMPOUND LINK
F2*
PART 2
(*Fi IS WEIGHTING FACTOR FOR PART i)
CHAIN
SEGMENT 1
SEGMENT 2
CHAIN 1
ANY POINT IN TIME
CHAIN 2

This notice is based on medical evidence from the toxicology groups, from the oncology wards and other sources. It appears that cognitive tasks are not degraded, but primarily with the degradations that we see it's certainly true in MOPP gear. From all of our tests in the field the degradations we see are in rate of performance.

The first human factors model we want to discuss is just a real simple one. Effectiveness of substitutes is the simplest algorithm we have. When the user specifies a truck driver, he says the guy who normally does this job is the guy whose MOS is such and such. He does it at 100%. It can also be done by a number of other people at 100%. There are individuals, however, that are only going to perform 80% of normal, and good commanders know who they are. That's the simplest of our algorithms.

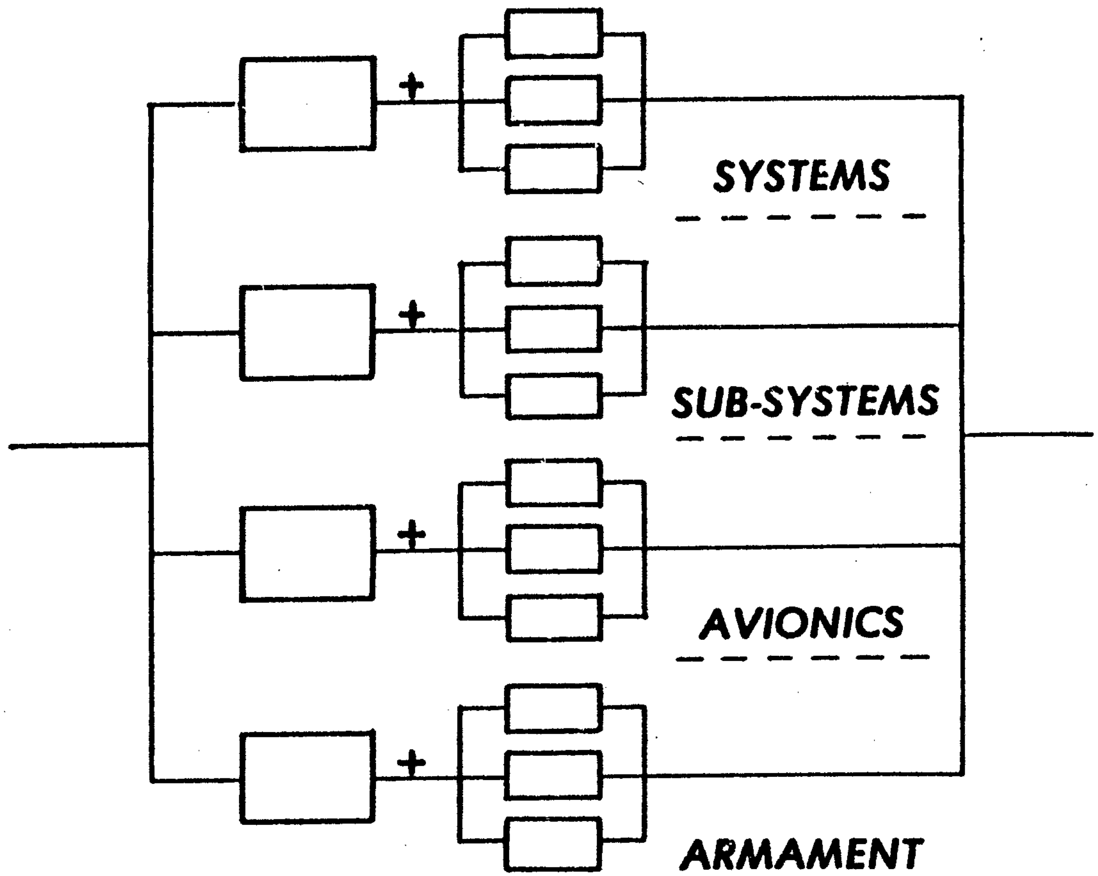
Somewhat more complicated is the effect of a nuclear dose. In the old models individuals exposed to nuclear radiation either lived or died. Suppose, however, you are using 3,000 rads for the kill criteria, and an individual received 2,999 rads. In the old model, he is fine. That was the model we were using until IDP. IDP was an extremely important project. What we do now is quantify the individual's performance. That fellow at 3,000 rads for the first couple minutes is still functional, and then he'll start degrading. But as a matter of fact, so will the person at 500 rads. He is going to last a little longer, and he is going to have a couple of hours of good work, but he is going to go into that prodromal phase too. So we no longer have this go, no-go break. AURA keeps track of the doses that everyone has and the time which they received it, and when a commander goes to assign a dosed individual to a job, then the code checks the guy's dose and his time pops into the curve shown in the next figure and determines what kind of degradation he should have at that time.

On top of this model (not shown here) is an incidence matrix. We have recently expanded the work of the IDP, because at low doses the effects are very dependent on individual differences. For these doses we now do a Monte Carlo draw against an incidence probability to determine whether an individual is going to be one of those who are sick are not.

So we use one level of sophistication beyond what is shown in the figure. It's certainly not a go, no-go situation any more.

No. 20

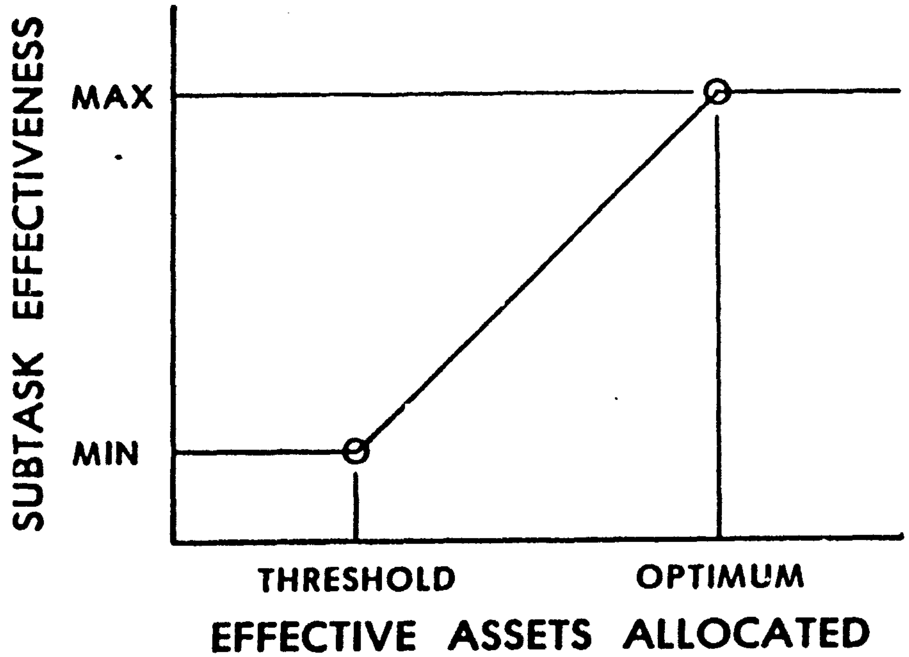
DIAGRAM OF HELICOPTER REPAIR FUNCTION



JUL 85

AMC - Providing Leaders the Decisive Edge

LINK EFFECTIVENESS CURVE

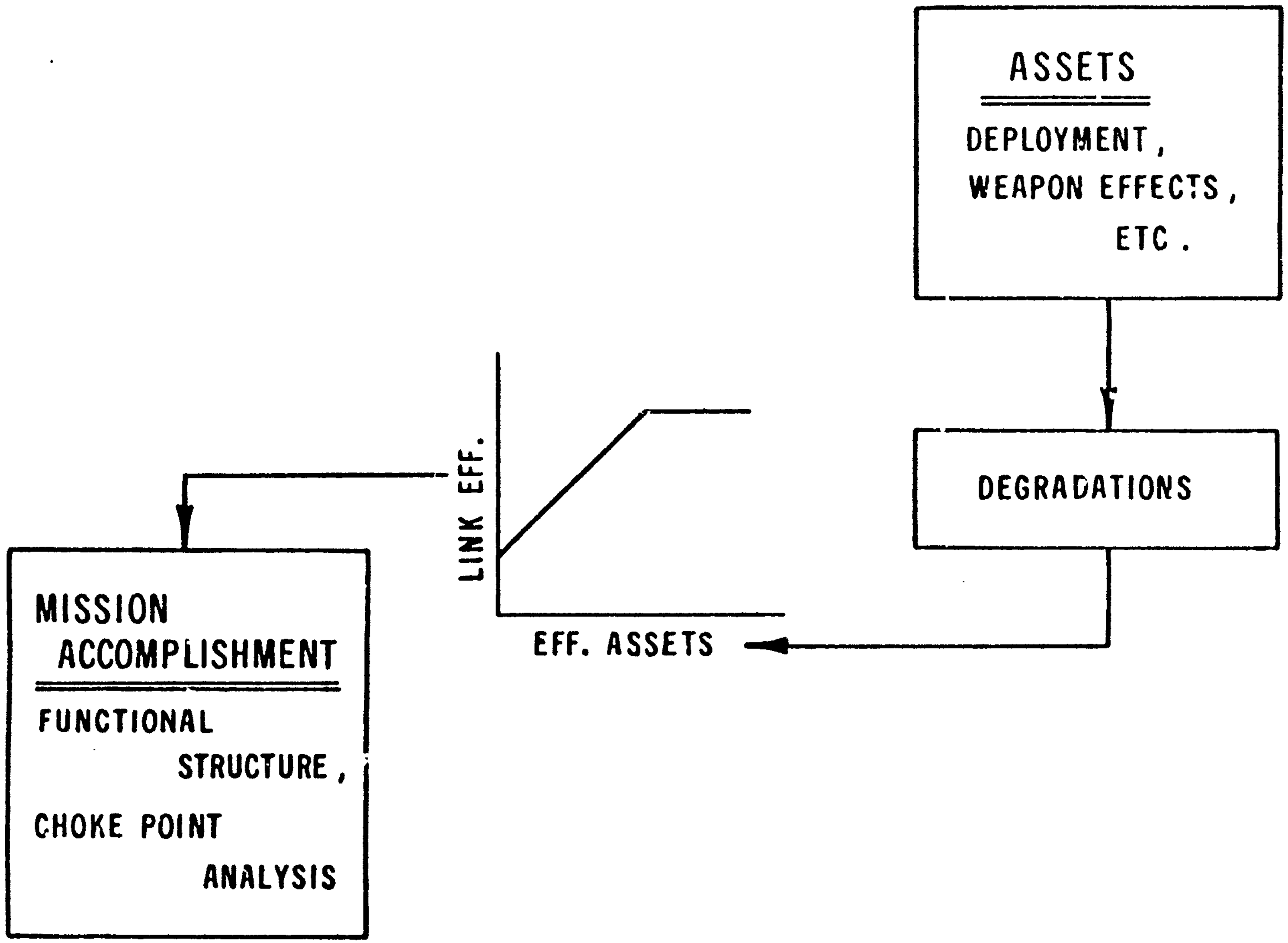


MAR 83

Simulation of chemical warfare is similar, but somewhat more complicated than nuclear warfare. It is really tough to keep track of those chemical clouds and where they go. It is also difficult to know what job each individual is doing, how hard they are breathing, and how long they are exposed to the cloud. A dose of chemical exposure becomes much like giving someone a dose of radiation, that is, there is a time dependence. So as a function of time the nerve agent victim also is going to have some degradation in effect, and then he is going to recover or he is not going to recover. He is going to get to some point where the medics say "hey, this guy is gone," and they give him a double shot of tupamechloride and haul him away and therefore he suddenly disappears from the group. Given that he is not yanked out of the scenario, his ability to perform a job if he has gotten, say, a tenth of a lethal dose, is going to be degraded. He is still there and he is still an asset. When push comes to shove, a commander might have to put him on a radio, or whatever, but his ability is going to be degraded.

An additional complexity to chemical warfare is the fact that even more than nuclear there is a tremendous variation in individuals, in individual susceptibility to chemical agents. The distribution of reactions to chemical agents is described by something that is called the "bliss slope," which is the inverse of a log probate slope. When a non-log scale is used, it looks like the cumulative log normal type of distribution. The distribution gives the percentage of the population at a given dose that would show certain symptoms. We have built this chemical model into AURA so that when the commander is trying to determine how well he can get his job done, the model looks at each one of his assignments and determines the chemical dose each individual has received. The model also checks to see where the individual falls in the population, i.e., is he one of the strong ones or one of the weak ones, and based upon that, how much he is degraded?

Clearly these are not models that we developed at BRL. They came out of the Chemical community. Primarily we got them through CRDC (Chemical Research and Development Command) but it's another algorithm that we have integrated into AURA. Biological warfare is something that people do think about, but for which we do not have a model. Biological effects will probably follow the same type of algorithm as chemical and nuclear, so we are not worried about whether we can make the connections or not. The biggest question regarding biological warfare concerns dissemination. Certainly don't count the number of spores. If anybody has any good algorithms, we are certainly interested in seeing them.


ASSETS
DEPLOYMENT,
WEAPON EFFECTS,
ETC.
DEGRADATIONS
LINK EFF.
EFF. ASSETS
MISSION
ACCOMPLISHMENT
FUNCTIONAL
STRUCTURE,
CHOKE POINT
ANALYSIS

AURA OUTPUT

TIME DEPENDENT

- QUANTITATIVE UNIT EFFECTIVENESS
- PERSONNEL AND MATERIEL LOSSES
- TASK PERFORMANCE AND DEGRADATION
- REASON FOR DEGRADATION (CHOKE POINT)
- MOST EFFECTIVE METHODS OF MISSION ACCOMPLISHMENT

SENSITIVITY ANALYSES

AUG 85

Human Factors Models

Effectiveness of Substitutes

Sublethal Doses

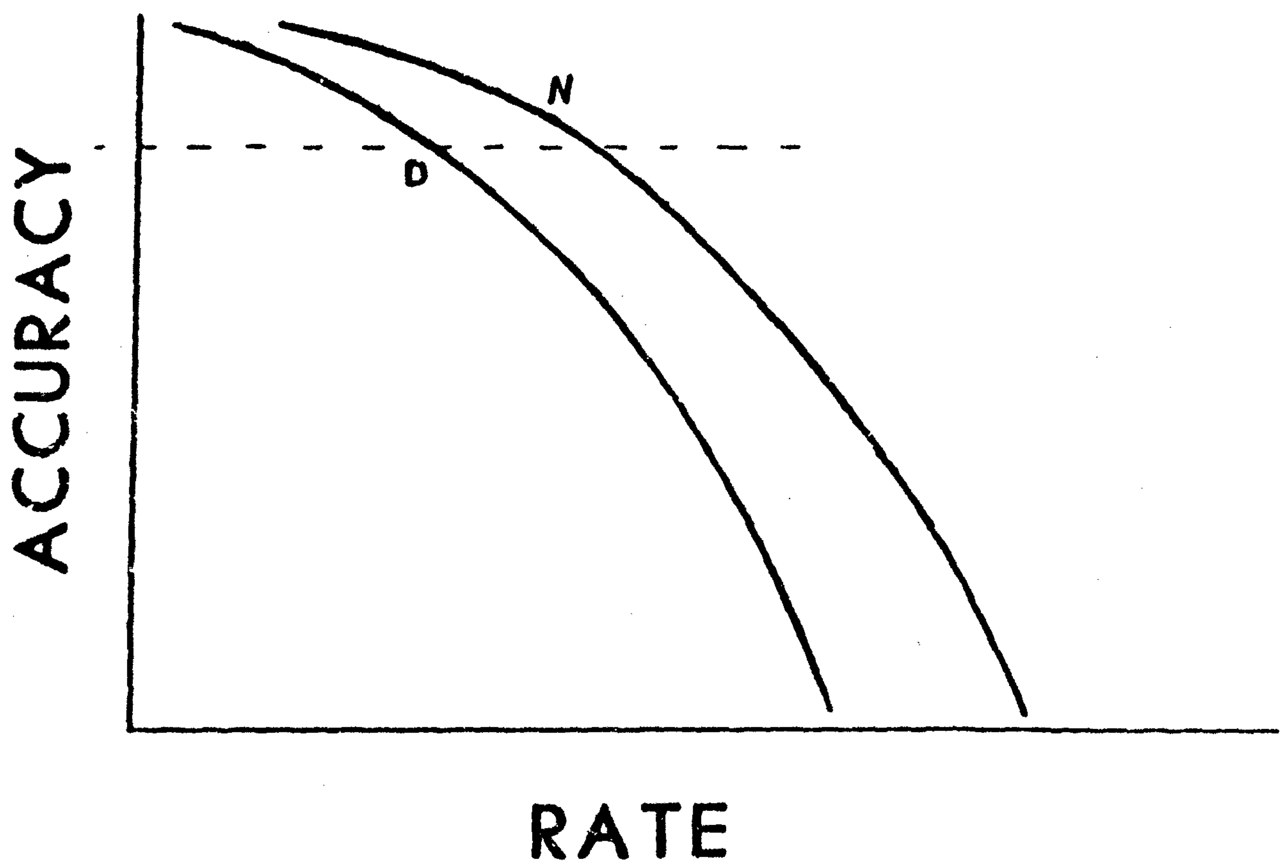
MOPP Degradation

Heat Stress

Fatigue

Psychological

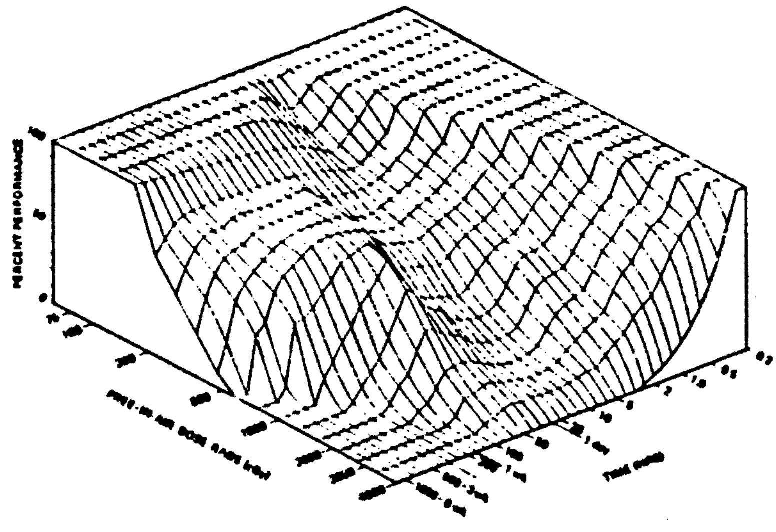
ACCURACY vs. RATE

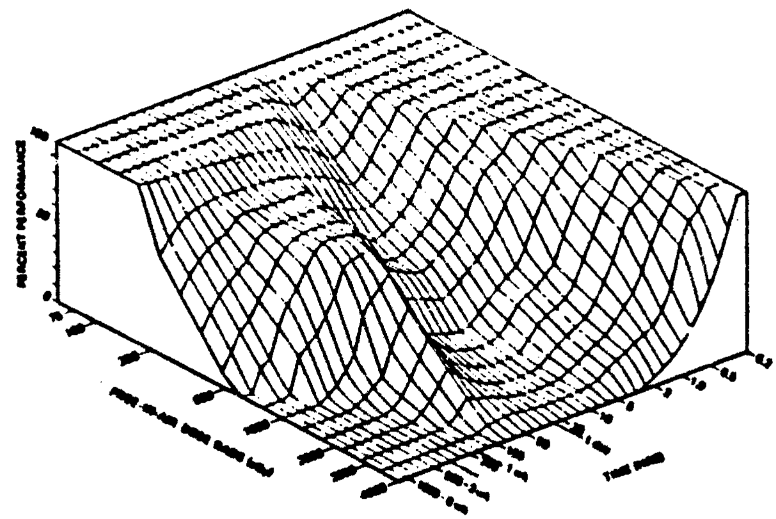


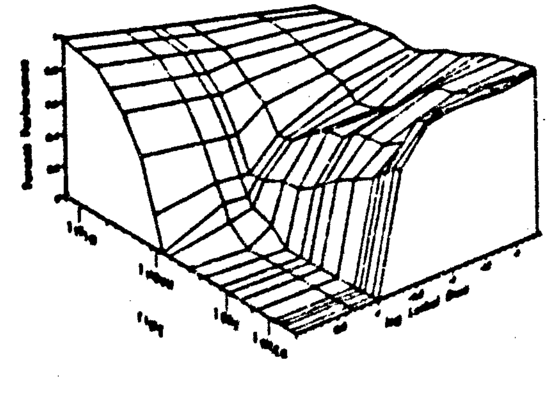
A related topic we are interested in is the effects of Mission Oriented Protective Posture (MOPP), chemical protection gear, on unit performance. What happens when you put on chemical gear? Well, you have a couple of effects that come out of chemical gear and both limit human performance. In a large number of the chemical studies we have done (including one for the Navy), the effects of putting people in the MOPP gear were really the dominant effects in the analysis. People in this gear really can't operate very well. The gear bothers them; there is an encumbrance, it increases the fatigue, and there is the possibility of heat stress. These are not unrelated factors.

Heat stress is a casualty producer, but I wanted to bring it here because there is this trade-off. In MOPP gear you can push people a little harder. You can increase the work rest-rest ratio, with more work and less rest, but the cost of that is an increase in body core temp. Metabolic work rate goes up, and there is an increased possibility of a casualty. This is a real effect commanders have to face out in the field. For the metabolic work rate, there are algorithms available. This particular algorithm is the one that we call T-Core. It is a program that we wrote but it's based on work that came out of ARIEM. USARIEM is the U.S. Army Research Institute for Environmental Medicine at Natick. A researcher by the name of Goldman did most of the work on heat stress and body core temperature build-up. The body core temperature is that function of starting core temperature plus heat capacity, and the sum of the energy flows. The energy flow reflects a number of different sources, but the most important is the metabolic work rate. The metabolic work rate depends on a resting rate that you can't get below, plus the amount of physical work an individual is doing. Based on this model we can play the trade-offs between degrading a person with MOPP gear by slowing him down and keep his core temperature under control, or let him work a little harder, and take a chance on heat stress. These are all human performance parameters and important ones to trade off against operational requirements.

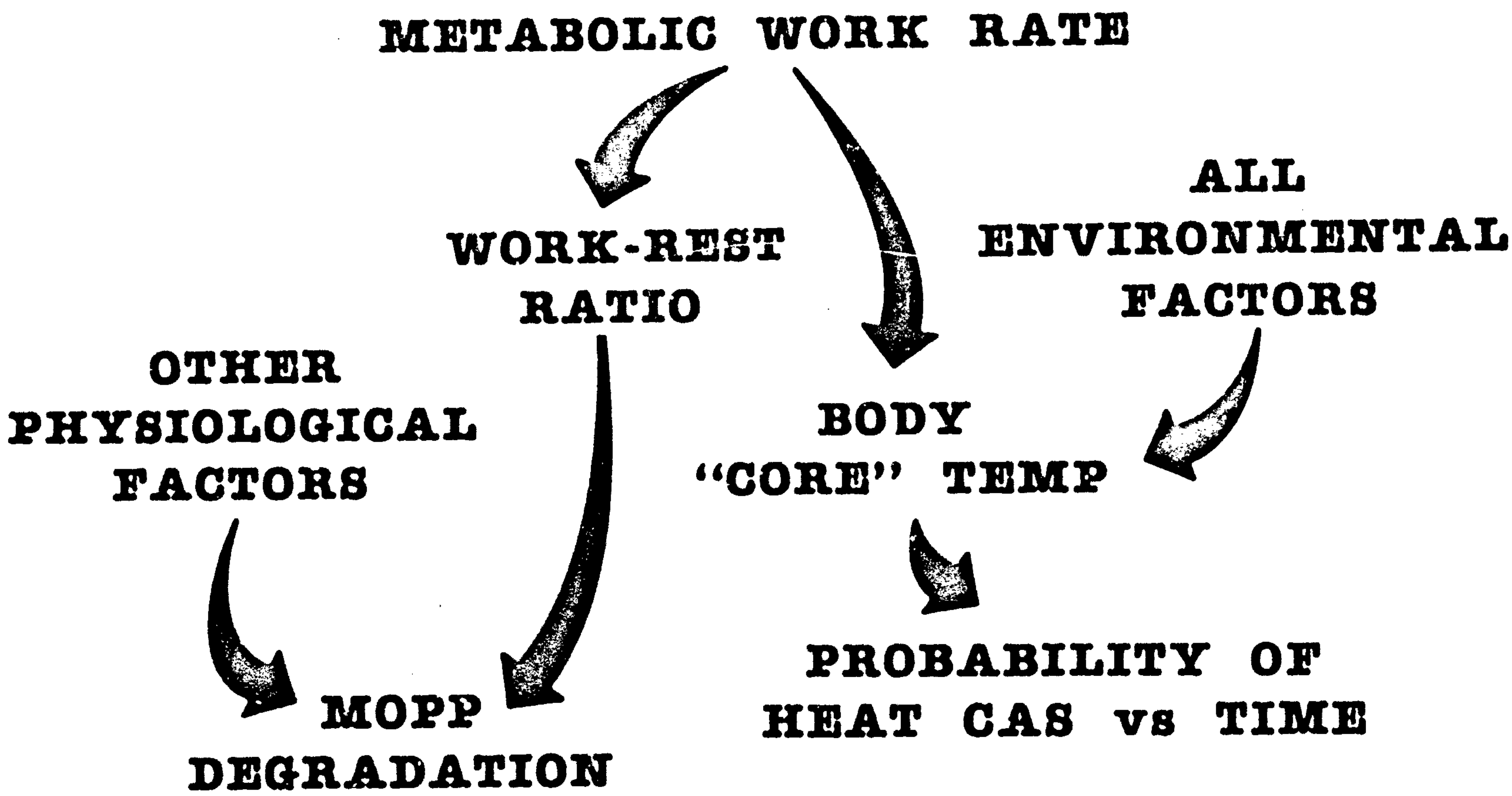
The final effect I want to discuss in terms of MOPP gear and chemical warfare is the idea of fatigue. Even if a person is not wearing MOPP gear, the normal working individual after a time is going to show a performance decrement. The time it takes will depend on the job and the individual. It may take 12 hours or maybe 24 hours, but it will happen.


PERCENT PERFORMANCE


PERCENT PERFORMANCE



Mopp Degradation ⟺ Heat Stress Casualties



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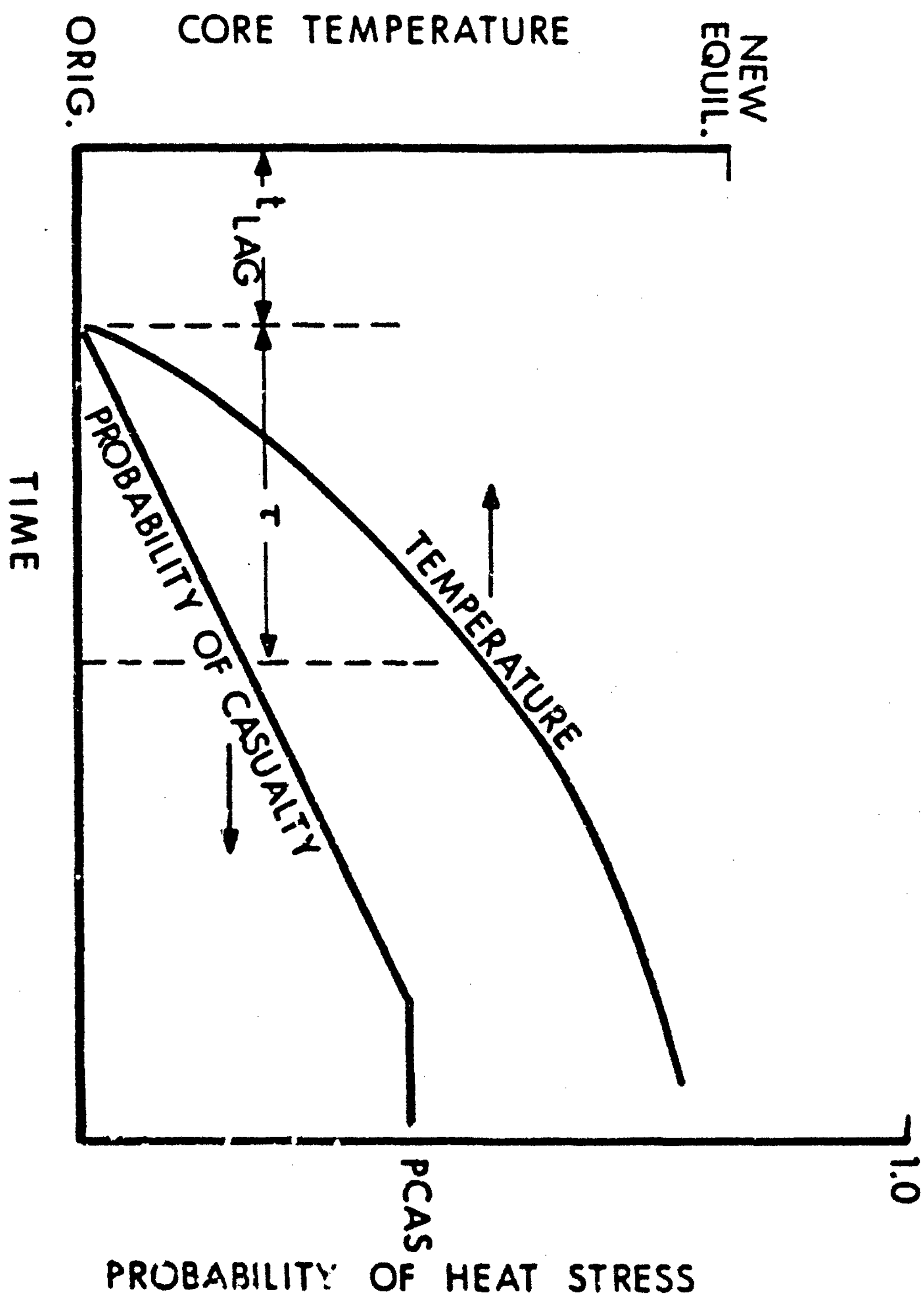
CORE TEMPERATURE
ORIG.
NEW EQUIL.
t LAG
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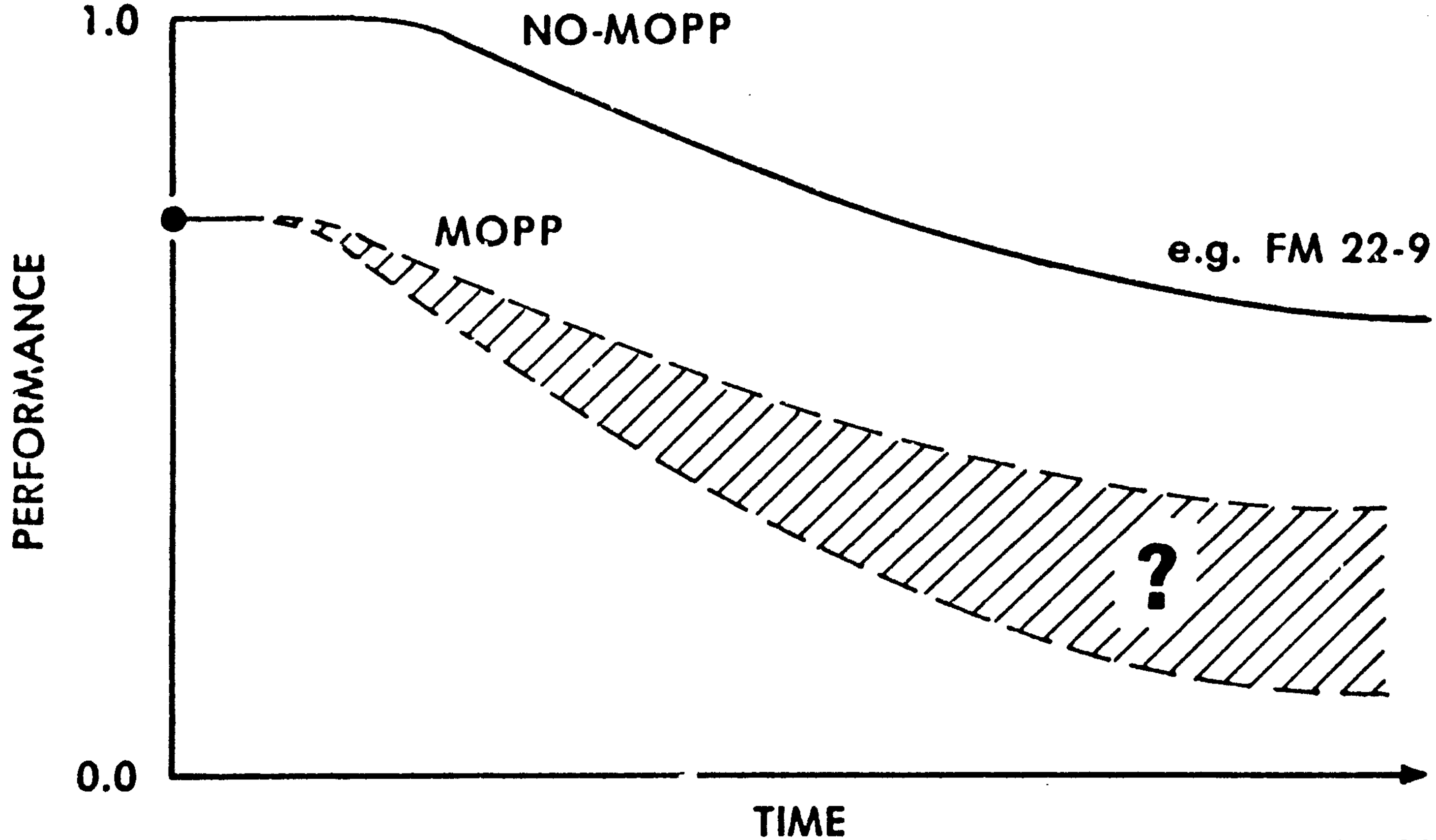
TIME
TEMPERATURE
PROBABILITY OF CASUALTY
PCAS
1.0
PROBABILITY OF HEAT STRESS

DEGRADATION vs TIME



APR 86

What happens when he puts on MOPP gear? Well, first of all he is encumbered. We have made large numbers of measurements to quantify the effects of this encumbrance. We have taken field measures of maintenance groups, and we have had marines running around on night recon patrols; plus we gathered a lot of information from the Air Force on maintenance tasks that they have done in and out of MOPP gear. These studies have given us a rather nice data base on how much an individual is encumbered by MOPP gear. As a matter of fact, we have set the NATO standards. There is a standard NATO technique now that is centered on the data base at BRL for how much an individual is encumbered.

Another effect of wearing MOPP gear is that the individual is going to tire more quickly. He tires more quickly even if he isn't working, because his metabolic rate goes up. His heart beat is faster and his respiration rate goes up, because that's the only way you can maintain the body core temperature and get rid of excess heat buildup. If he is going to tire more quickly, that means that his performance will drop a little more precipitously. We don't have a great deal of information on this yet, but it is an area we will be working on. MOPP gear will be another module in AURA. When a unit commander goes to assign somebody to a task, the model will check to see whether he is in MOPP gear or not, and how long he has been in MOPP gear. Based on these factors, along with information on the last time he rested, he places him on a curve. The curve that we use now is linearized, and one of the contacts I have already made at this meeting, Dr. Naitoh, suggests that we can do better than the linear model.

In the model now we store up what I call sleep units, "slunits," which an individual then uses at some rate that depends on the job. How fast he uses these units up depends on the job, and how many he needs for 100% effectiveness is also job dependent. When the user describes the various jobs, he has a couple of parameters that describe the demand, and the tiring rate of the job. The individual works until he drops below a certain number of my "slunits," at which point his capabilities start to decrease. One of the things that AURA does being a very smart commander, is it makes the decision whether he wants the individual to sleep or not. Can I do without this asset? If I do without this asset what does it cost me, and what am I going to gain if I put him to sleep?

The last issue I want to just touch on is psychological. We do not yet incorporate psychological effects in the model. We are in the process of installing the first stage of psychological effects. The psychological effects that we are installing will be catastrophic ones, that is, the increase in casualties due to the production of neuropsychiatric (NP) casualties is based on a magnificent piece of work by Dr. Levin. This is also work that came out of the intermediate nuclear dose program funded by Dr. Young. The psychological information that is available deals with very severe cases, and will be used in the model as a casualty multiplier.

That pretty much summarizes what I wanted to talk about. I have given you a flavor for the algorithms that are in the model, how they hook into a code, and what kind of effect they make. Based upon the comparisons we have made the results appear to be quite realistic.

I would like to leave you with one final point. Anyone that suggests that he is leaving a variable out of his model because it can't be simulated, is telling an untruth. The absence of a model is a model. If you run a study, and you come out with an answer, you have played absolutely everything. It's just that some things you haven't played terribly well. You have played some of the factors by multiplying by one. The offshoot of this is that a model that gets some of the characteristics certainly has to be better than pretending you are not playing it at all, because you are playing it. If we get people to just not last forever, that has to be an improvement. If we show that not everybody is 100% gung ho in the face of fire, we have done something, and we probably made an improvement.

The absence of a model is a model.

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G-27-685

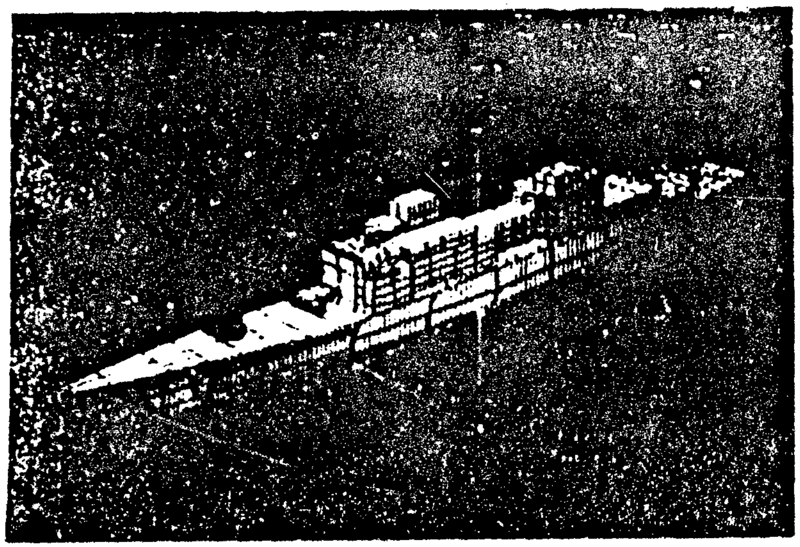
NAVAL CAPABILITY ASSESSMENTS OF FORCES AFLOAT TO CB THREATS

UNCLASSIFIED

THOMAS J. YENCHA
NAVAL SURFACE WEAPONS CENTER
DAHLGREN, VA 22448

CHEMICAL/BIOLOGICAL/RADIOLOGICAL DEFENSE - PE 62233N

CAPABILITY ASSESSMENTS OF FORCES AFLOAT TO CB THREATS



TECHNICAL ISSUES

- CW AGENT EFFECTS
- THREAT/TECHNOLOGY IMPACT
- SHIP MISSION DEGRADATION
- MODEL DEVELOPMENT
- DATA ASSUMPTIONS
- SHORTFALL PREDICTION METHODOLOGY

DELIVERABLES

- NAVAL CBW ATTACK MODEL
- NAVAL CBW CASUALTY ASSESSMENT MODEL
- NAVAL CBW MISSION DEGRADATION MODEL
- METHODOLOGY TO PREDICT CBD SHORTFALLS IN THE FLEET
- NEW THREAT MODIFIERS

OBJECTIVES

- DEVELOP NAVAL CBW ATTACK MODELS
- DEMONSTRATE NAVAL CBW ATTACK MODELS
- CONDUCT CAPABILITY ASSESSMENTS TO CB THREAT OF FORCES AFLOAT
- PREDICT CBD TECHNOLOGICAL SHORTFALLS IN THE FLEET
- DEVELOP CBD 6.2 INITIATIVES

ADDRESS BY DR. THOMAS J. YENCHA

My name is Tom Yencha. I am the principal investigator and program manager for the Naval Capability Assessment of Forces of Threat. Before Paul Kirk tells you about NURA, I wanted to give you some background on the project.

We developed our system of models as a tool to perform a job. Our project was not a project to develop a model, we had to do that because there was nothing else available that would do what we wanted to do. What we wanted to do was to predict CB defensive technological shortfalls in the present fleet, and then list 6.2 R&D initiatives that can be started to relieve these deficiencies. We started this project in 1982 - 1983, and at that time there were no models available to predict the fleet CB shortfalls, or to develop initiatives to alleviate the shortfalls. Therefore, we had to come up with our model.

The next figure is a kind of a line drawing to shew you our methodology. This model is in some ways new work, and in some ways modifications of old work. The acronym DAWN stands for a rather long name: Deposition and Weathering of Chemical Agents about a Naval Vessel. That model has been developed in the past four years, and it's predicated on the News Eye; the Army News Eye (NUSEY) methodologies. But as some of you modelers might know, the NUSEY methodology is a table top model which lays down liquid deposition and vapor movement on a flat plane, and it has been evolving to take into account three dimensional barriers. In 1983 it didn't have any of that capability, and even now it doesn't have the capability to put a small barrier and give you accurate dosages and/or concentrations around that barrier. We feel our model does. What our model needs to operate, is information that describes our operational situation; things like direction of movement of a ship, people needed to operate the ship and so forth, and we also have a digitized ship data base that gives a picture of what the ship would look like.

We input this information into the DAWN model along with the operational situation, and the types of weapons and locations of those weapons that are attacking the ship. The DAWN model tracks the deposition of liquid on the ship from the release of the agent through its evaporation and dissipation. The model tracks the distribution of the agent concentration as a function of time, and feeds that data into another model. At the time I did this flow chart, it was called the SHIPPEN model, but since then we have modified that model and call it the ventilation model. The model covers the mechanical transfer of the agent through the outside of the ventilation system into each of the compartments inside the ship. The output of that model is a time history of concentration and/or a time history of dose in each of the compartments of the ship. In order to operate the SHPPEN model, we need our Operational Thread Environment, and we need rather an extensive data base for the HVAC (heating, ventilation and air conditioning) data. HVAC data is a description of the ventilation of the ship.

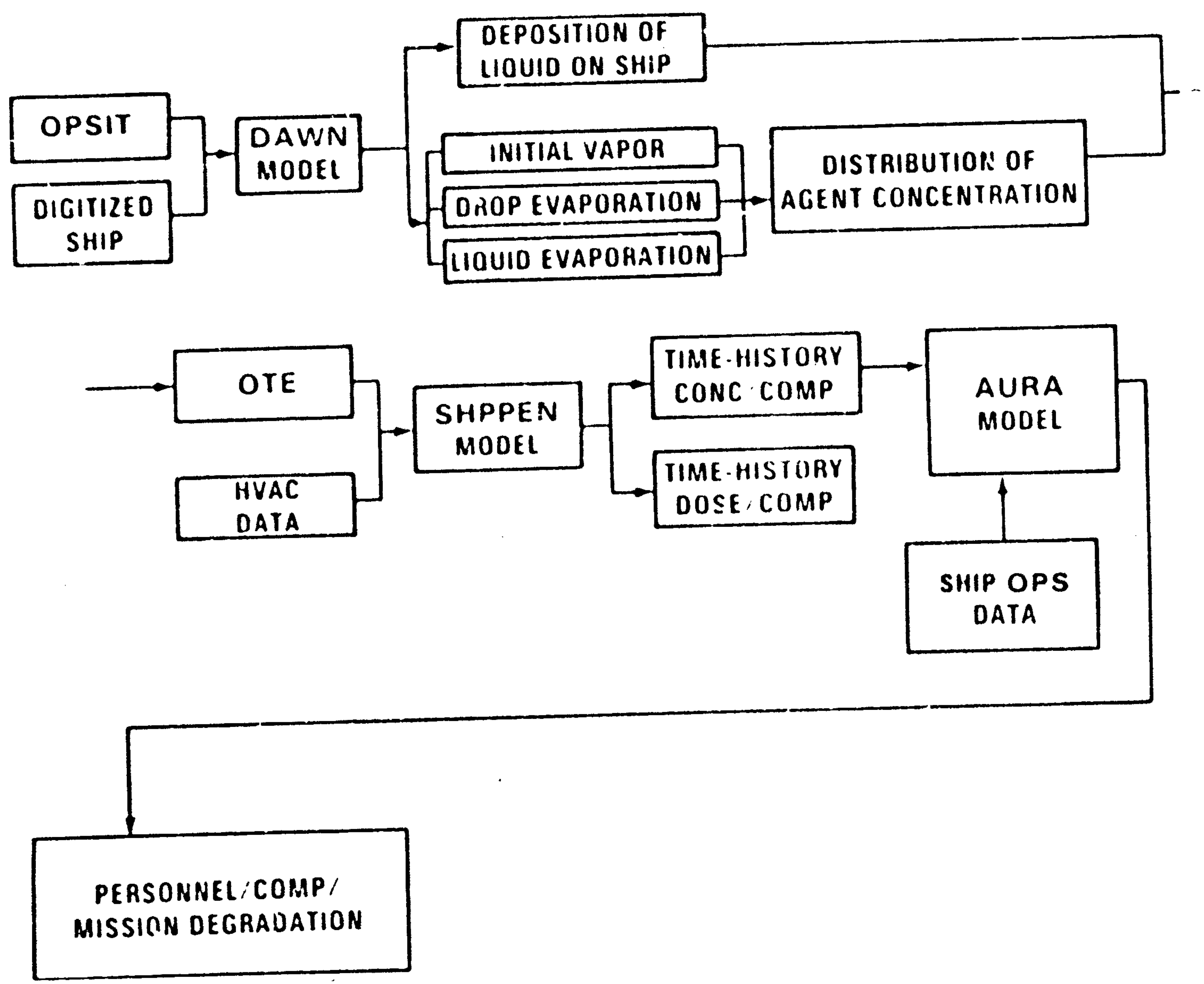
We track an agent from its point of release to the vicinity of the ship using the NUSEY model or a variation of the NUSEY model. Once the agent gets approximately 80 to 100 feet away from the ship, there are three dimensional effects of the ship itself that perturb the wind field around the ship and you no longer can really satisfactorily use the NUSEY model. At the present time we are using a potential flow model to model the agent vapor transfer around the ship. We still use the NUSEY methodologies to transfer the liquid down to the ship surface itself. We also use a couple other models. If you are getting the idea that our model is a group of submodules, you're correct. It's structured in some ways similar to the AURA model.

One of the models we use is an Army vehicle deposition model that was developed by a contractor for the Army. It was basically developed to describe the impact of a liquid agent on a moving tank, and then track the evaporation of that agent off the tank. We have modified that model to describe the ship environment.

Obviously the resolution in our models is significantly higher than the resolution you have been talking about in your ground force simulation models. Most of the other models that have been talked about use a resolution of a couple hundred meters. We are talking about pieces of a ship that are on the order of meters in resolution.

The next thing I would like to talk about is the graphical output from this model. We use extensive graphics, and the next three figures show the type of output we obtain from our model. We are using basically a MicroSAINT computer to run the simulation itself. For graphic output we had previously used the Tektronics 4125 terminal, but we have since switched over to Emulations of that terminal on an IBM PC 386 type of computer. Using the IBM is significantly cheaper. The Emulation only cost us $900, and the computer itself was significantly cheaper than a 4125. Plus the 4125 that we had, we paid just under $30,000 for that terminal, and it did not allow us to capture any of the data that went to the screen. We could put it on the screen and then we could print it,

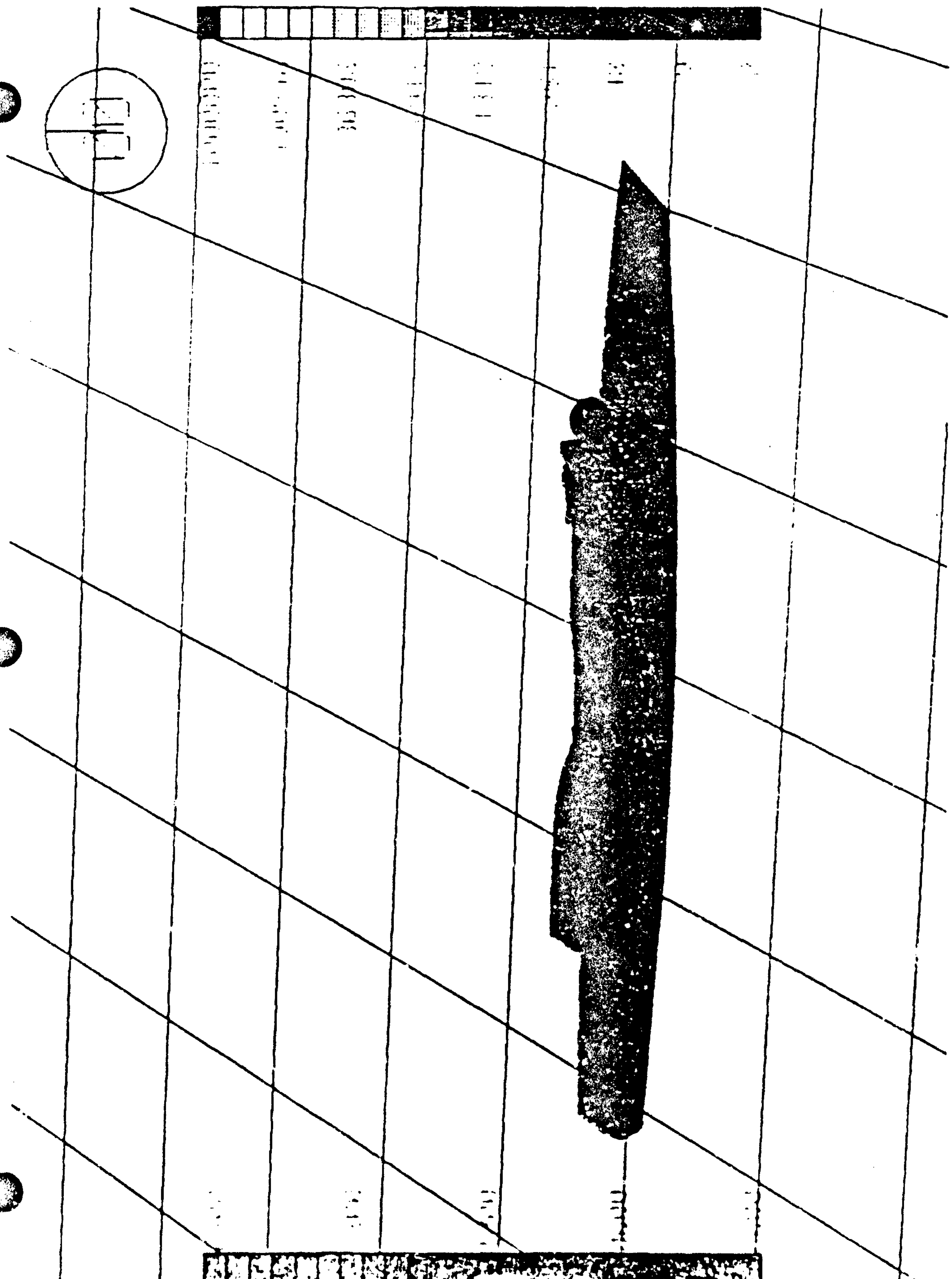
CAPABILITY ASSESSMENTS METHODOLOGY

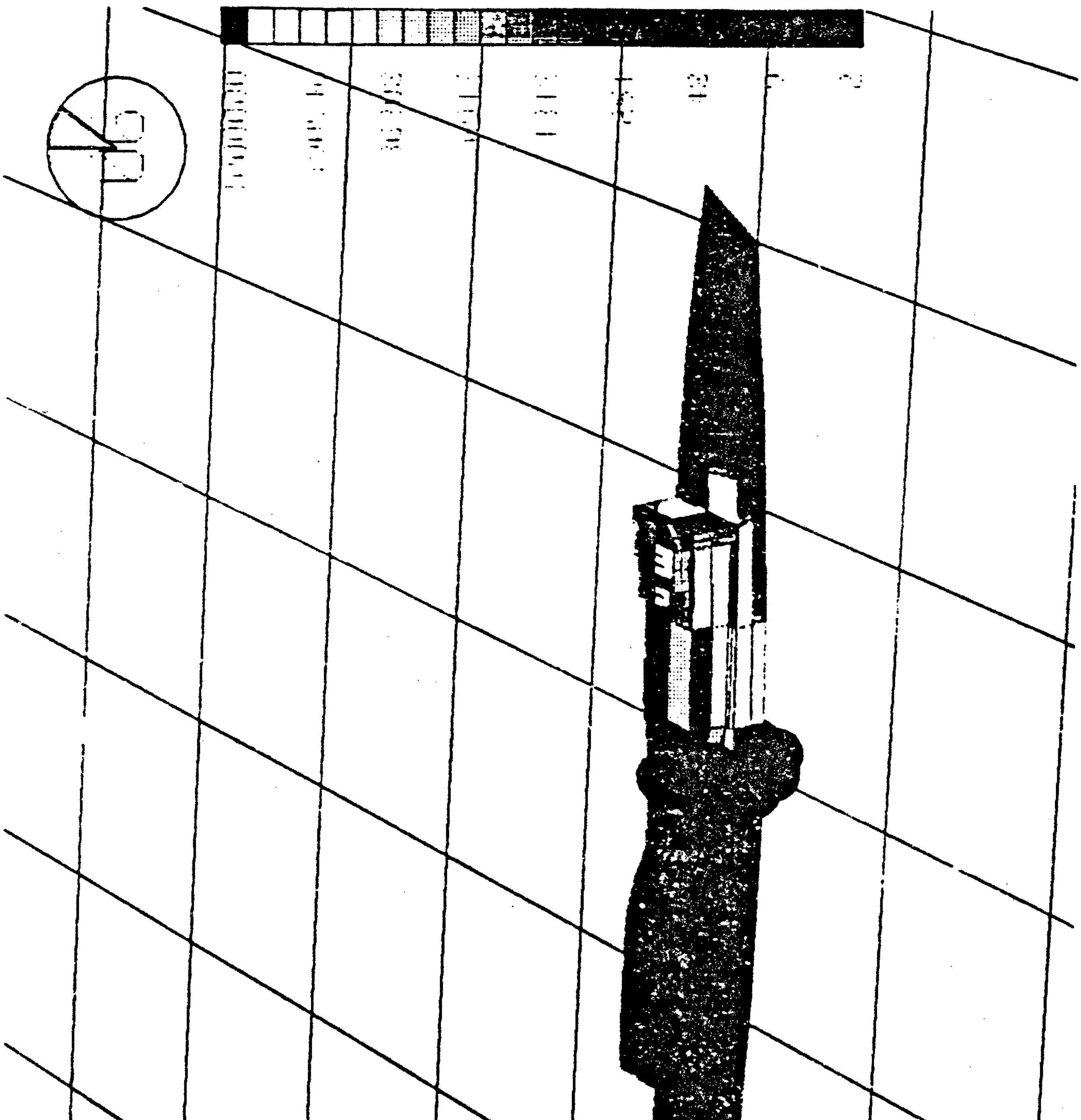


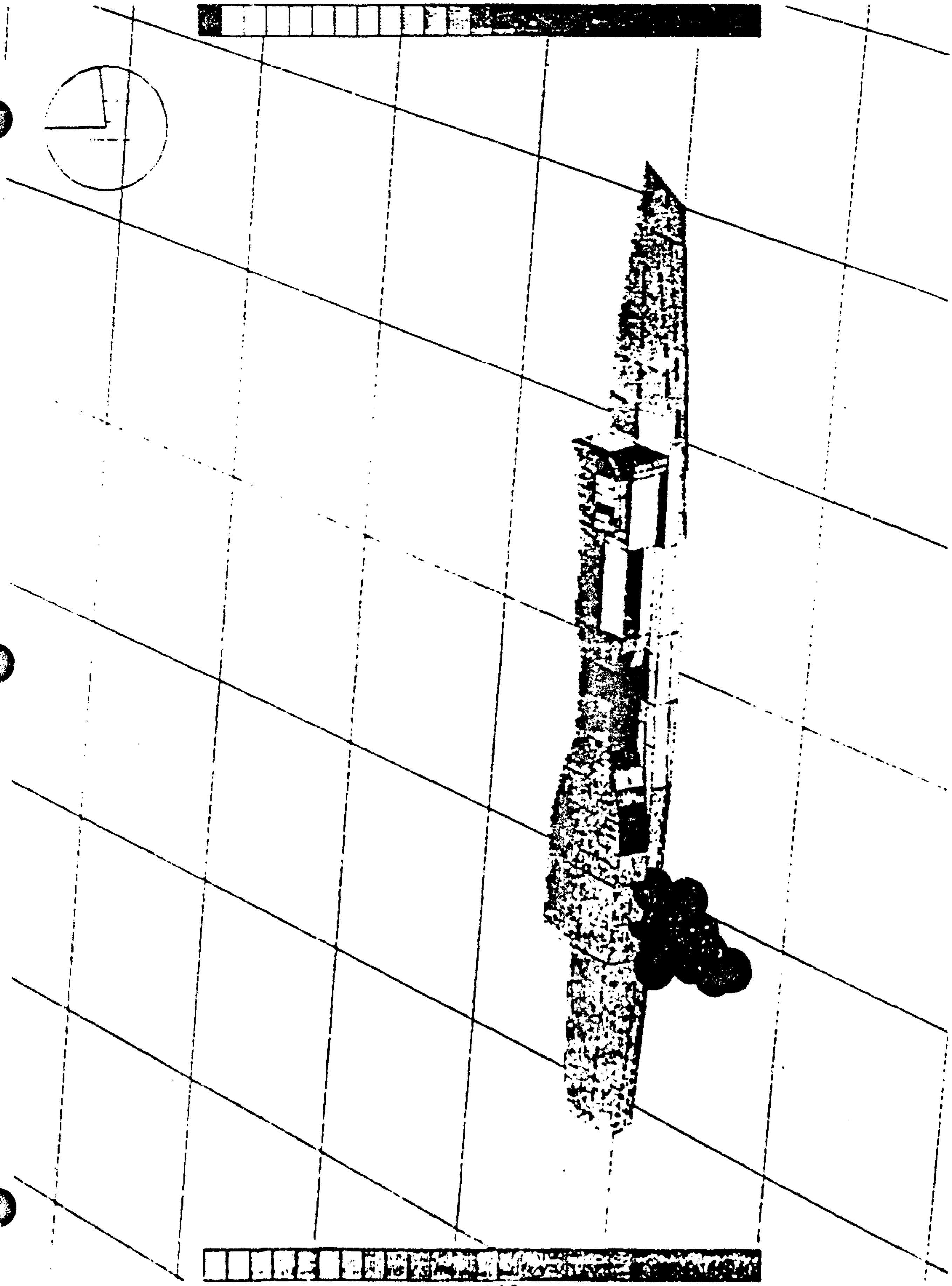
but that was it, and it takes a rather large amount of time to put graphics on the screen. Our ship model graphics take approximately five minutes. The model puts out a graphic image every one second of the attack. If we are going to spend four or five minutes on each graph, it will take a large amount of time for a single attack. Also, it would not allow us to demonstrate the model effectively to anybody else. With this PC 386 Emulation it takes us about half the time to put an image on the screen. But the system allows us to save images to a disk, and recall them back in two and a half seconds, so in terms of demonstrating it to our sponsors and other people, it is more effective.

The first figure shows the attack of a real intelligent weapon. It burst right in front of the front bulkhead on an FFG class ship. Six seconds later the cloud has moved aft. On the computer screen we have colored the different sections of the ship to indicate different liquid depositions in grams per square meter. We also see how all the liquid clouds are splitting up. We have started out with that single cloud, and as time progresses the single cloud will separate into multiple clouds, depending on the mass and radii of the liquid droplets in the cloud. At the time of 14 seconds the clouds have progressed further down the ship. This ship is moving at 20 knots. In the space of approximately 25 seconds this ship is no longer interacting with the clouds of the weapon release. The ship is still interacting with the evaporation of the liquid off the surfaces, but basically the attack is over and the weapon can no longer effect that ship. The time that we have to react to the attack is much less than you have with models like the scenarios that you would have in the Army or Marine Corps.

Basically, that's all I wanted to tell you about the NURA precursor models. The NURA model we use is different than the AURA model in that instead of representing a two dimensional Army battlefield, we have strung the compartments in the ship into a one dimensional array, representing the functional description of the ship. We have been putting out a lot of reports on various weapon types and ship types using the model. I have five technical reports being published right now.







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Naval Unit Resiliency Analysis

(NURA)

Paul Kirk

Naval Surface Warfare Center

Chemical Systems Branch

Dahlgren, VA

NSWC's Models

Deposition and Weathering of Chemical Agents about a Naval Vessel
(DAWN)

Ventilation Model
(VENM)

Naval Unit Resiliency Analysis
(NURA)

ADDRESS BY DR. PAUL KIRK

My name is Paul Kirk, and as Dr. Kolpcic mentioned, we use a version of the AURA model that we call NURA (Naval Unit Resiliency Analysis). We have applied the NURA model to the very specific area of Navy chemical defense. To do this, the two models that Tom mentioned, DAWN and VENM (Ventilation Model) were developed. Their output provided the input for the chemical warfare side of NURA. We do not use the nuclear and conventional warfare capabilities of AURA, but we have plans to combine that with the chemical warfare side in the future.

To adapt the AURA model to naval scenarios we made the changes mentioned, and have developed a utility program to map the two dimensional grid of AURA onto a one dimensional system. We take the chemical contamination, location, and time history, and map them onto a one dimensional grid. We also map the personnel deployment on the shipboard onto the same one dimensional grid so that they can be compared directly with the dosages that the personnel receive, and we can evaluate the results. All this is done without changing the functional structure of the AURA model.

Human response to CW attack is the only indicator of forces resiliency. We use the one factor that Dr. Kolpcic mentioned, the effect of these weapons against equipment. The only thing we use to measure the impact of an attack is human response. There are several human response data requirements for chemical warfare modeling. The MOPP degradation, and the toxic agent effects. Currently there have been a number of studies done to come up with MOPP degradation values, and I haven't seen great agreement amongst the studies that I have seen. The Navy currently has a doctrine of using strictly a protective mask for personnel located interior to the ship during vapor agent attacks. This is a Navy doctrine, and as far as we have been able to determine, nobody has actually studied this problem to see low degradation values adjust.

The toxic agent effects are divided into three areas. First, the sublethal effects are symptoms that cause performance degradation without actually killing the person. The amount of agent needed to do this can be considerably less than a lethal dose. The second point concerns the onset time of effects, which is the length of time after exposure to an agent before the poor performance degradation becomes apparent. Agents currently available range from a few minutes to several hours for onset times. And, the third point is lethality. Toxicity values are given in lethal dosages for 50% of

In Chemical Warfare modeling, human response is the only yardstick to measure the impact of an attack against a combat unit.

the population so that chemical casualties can be calculated on a statistical bases. The NURA model combines all three of these factors and comes up with an aggregate effectiveness value.

As an example of the type of study we do, the next graph shows the effect of varying amounts of agent against a single unit, a damage control unit on a ship. As you can see, increasing the amount of agent above 20 kilograms has no greater impact on the unit's effectiveness. This is the type of study we do to evaluate alternatives; see what amount of agent would be realistic to expect.

Each ship is divided up into several functional units. The units are listed here on the right, and we studied them individually and as a whole. These units are functional and have no relationship to Navy administrative organization. They are strictly organized this way because they are combined together to do one mission.

As you can see, the net effectiveness of this single ship is somewhere between 60% and 0%; probably closer to zero since the pilot house unit which steers the ship and the CIC unit (the combat unit which fights the ship), are both down here at zero and the ship is effectively out of the battle.

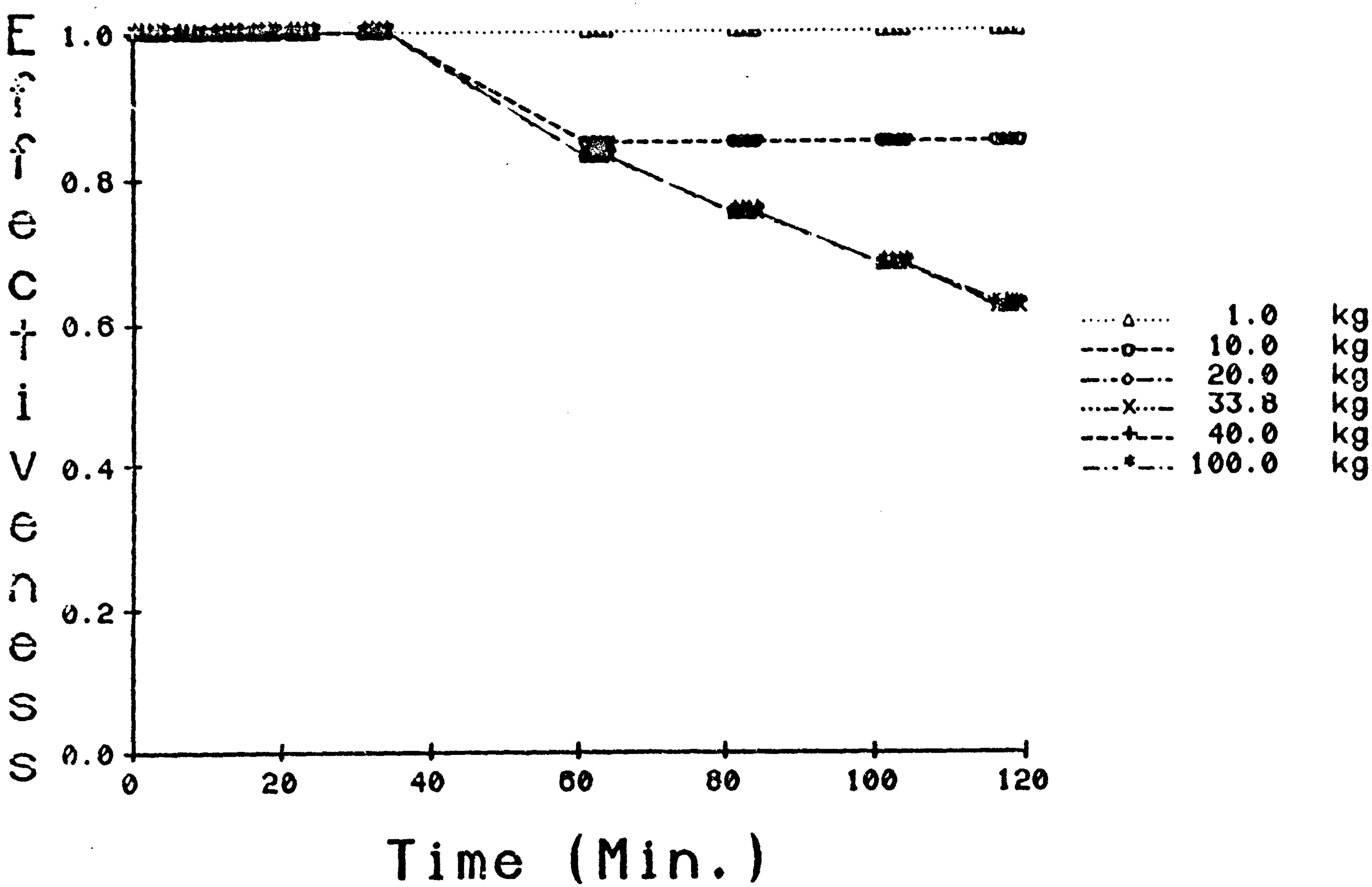
This is a list of the NURA data bases that we have gathered to date at Dahlgren. We have tied to collect most of the surface combatant classes on the one side, and most of the amphibious assault ship classes on the other.

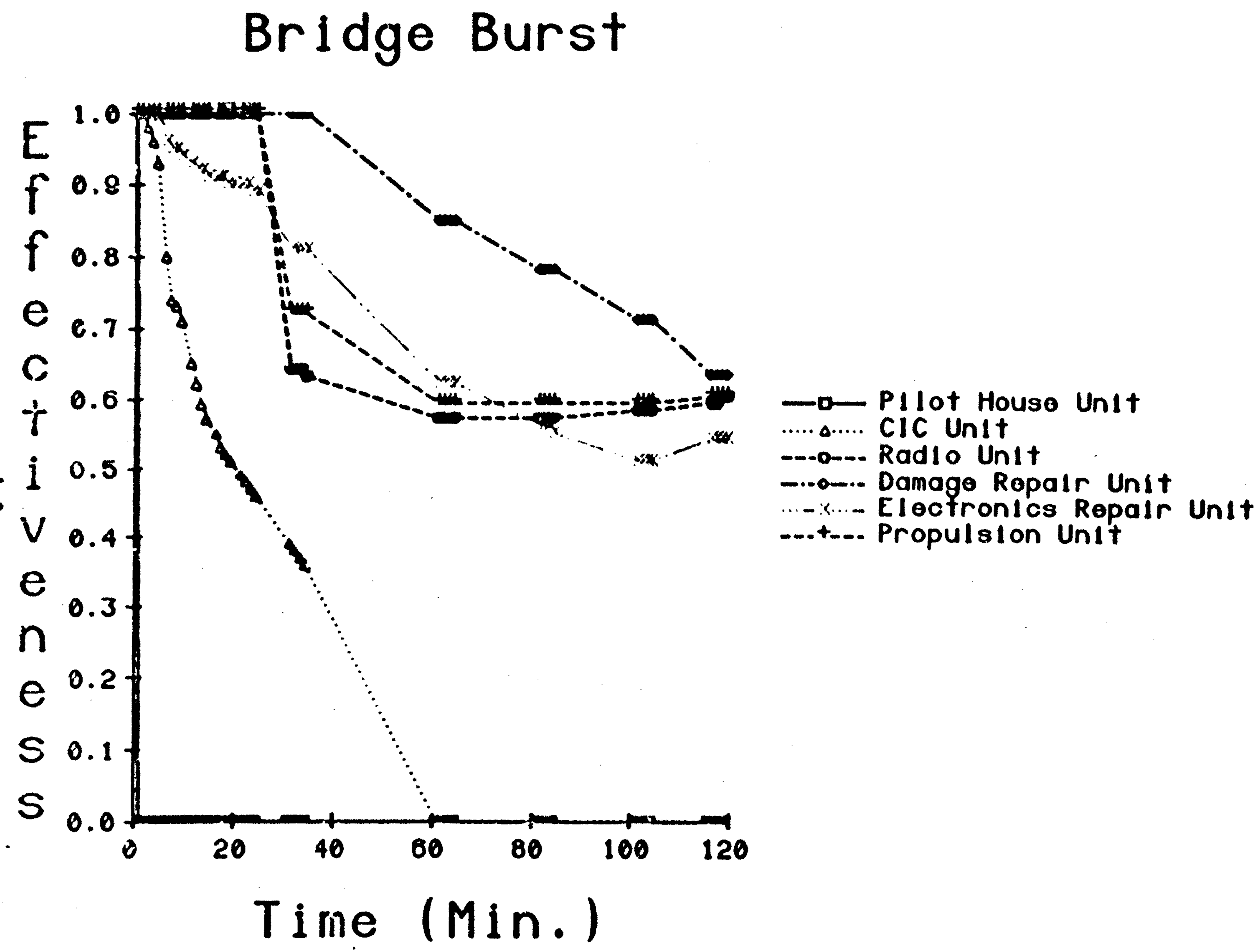
As Captain Jones mentioned, we don't have plans to gather any more, although if someone submits a specific requirement and the necessary funding, we can go off and gather it for them. We have recently completed a number of different studies. The first one should be in distribution around the first of the year and the others should follow shortly thereafter. All of the studies to date have been very simplistic scenarios of a single munition versus a single ship. These are funded applications, and we intend to continue them.

We would like to study an amphibious assault and extend the single munition against a single ship to several munitions against several ships in an amphibious task force. We would also like to use the model for various exercises, and establish a 100% performance base line, so that when we come back and say they are at 60% effectiveness, we can explain exactly what that means. As far as further developments for the program are concerned, we have a fairly short wish list. We would like to obtain some validated and corroborated MOPP degradation data, and we would also like to get the mask only degradation data, which is needed for the Navy.

The chemical warfare modeling office at Dahlgren is extremely small. There are three people full time, and a few people part-time on the project, and none of us are human performance experts. We would like to bring in an expert, and have him evaluate the model from his point of view and give us some useful input from that.

Damage Control Unit with
1 to 100 Kg Agent Burst in CIC





Bridge Burst
Effectiveness
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
20
40
60
80
100
120
Time (Min.)
Pilot House Unit
CIC Unit
Radio Unit
Damage Repair Unit
Electronics Repair Unit
Propulsion Unit

Ship Class Databases Currently Functional at NSWC

FFG-7	LHA-1
FF-1052	LPH-2
DD-963	LSD-36
DDG-993	LPD-4
CG-26	LST-1178
CG-47	

Databases Currently Under Contract to Obtain

CVN-68

CGN-38

Studies recently completed by NSWC

Impact of a Penetrating Chemical Warfare (GD filled) Round Against an FFG-7 Class Ship

Impact of a Penetrating Chemical Warfare (GD filled) Round Against a DD-963 Class Ship

Impact of a Penetrating Chemical Warfare (GD filled) Round Against a LST-1179 Class Ship

Impact of a Penetrating Chemical Warfare (VX filled) Round Against an FFG-7 Class Ship

Planned Applications

Continue studies of single CW munition versus single ship

Study NBC Defense technology impact on amphibious assault in a CW environment

Validate model for naval scenarios and obtain baseline (100% performance) data

Planned NURA Work

Obtain IPE/MOPP Degradation Data

Navy unique data required i.e. Mask only degradation data

Evaluate the model from human performance evaluation perspective

Implement more flexible MOPP and unMOPP options

TASK NETWORK MODELING AND MICRO SAINT

APPLICATIONS TO HUMAN PERFORMANCE IN COMBAT MODELING

Presented at the Conference on
Computer Simulation of Human Combat Performance

Lawrence Livermore National Laboratory
30 November 1988

Dr. Ron Laughery
Micro Analysis and Design

ORGANIZATION OF THE PRESENTATION

- Introduction to task network modeling of human performance
- Presentation of the Micro SAINT computer simulation language
- Presentation of some of the related Micro SAINT projects
- Discussion of how task network modeling concepts can be applied to incorporating human performance variability into combat models

ADDRESS BY DR. RON LAUGHERY

DR. LAUGHERY: What I am going to be talking about this afternoon basically is going to be a technique called task network modeling, which has kind of manifested itself in MicroSAINT over the last couple of years. What I have been doing for about the last ten years is working on human performance modeling, and the work at MicroSAINT has developed out of this effort. What I hope you will find at the end of this presentation is that the MicroSAINT model is really a very nice technique for bridging the gap between human performance models and combat models.

I would like to cover four items in this presentation (see figure).

First, I want to give everyone an introduction to what I mean by task network modeling. Second, I want to talk about the MicroSAINT computer simulation language, largely because that's the title of this talk. Thirdly, I want to talk about some related MicroSAINT projects. One is very closely related because it draws a nice link between combat modeling, human performance modeling, and ultimately the overall picture of system performance during the system design process. Then fourth, time permitting, I want to talk about how the concepts of task network modeling of human performance can be incorporated into combat models.

First, let me try to cover the topic of task network modeling, kind of set the groundwork as to what is meant by the term. Essentially, "task network modeling" involves the decomposition of a series of human activities into a set of discrete tasks, and then defining their sequential relationships primarily through a network. Really nothing more magical than that. In essence, we are going to take what a human does, but it doesn't have to be human. Tasks can be all sorts of things. They can be human tasks, or they can be system tasks. The first thing you do when constructing a task network model is you break the process down. Some of the kinds of models we have been creating include one for an M-60 tank crew on a one-on-one engagement with an automated target recognition. We break down the tasks of each of the four crew positions so we have what everybody is doing in time and how they are interrelated. We have compared the automatic target recognition approach with the manual target recognition approach, and evaluated the different network models you get. This allows you to play the "what if" game in performance. Those are not the only elements of a task network model. Once you have defined your network, you have some other homework in at least three areas. First, you have to define obvious think time component task so you can determine the time to perform each task. These task times will drive the simulation. Secondly, you want to look at the effect that each task has on other tasks. For example, when one task involves depressing a button, that button would probably initiate a series of activities in the system, the hardware response to that button being pushed. The task could also involve the consumption of resources. The beginning of this task uses some piece of equipment that's now no longer available to the other people in the operation you are simulating. The third thing you must define is the conditions required before the task can begin. This can be like resource availability; resource in terms of the individuals or resources in terms of equipment, etc.

Now, a few extra words on task network models. First, they are really designed to be represented in an event driven simulation. I don't want to get into a discourse on different types of simulations, but there are basically two kinds. Our model is event driven where the beginning of a task is dependent on the completion of some other task, and so on down the line, but the events make the simulation clock move forward. Network models are generally designed to be agreed upon models as opposed to frame models, where every second, or ten seconds, or two hours, you evaluate the state of the system, you evaluate the passage of time and the state of the system at the beginning of that frame time and what might have happened during that frame time. Task network modeling is like most network models in that they provide primarily a discreet event time simulation. We have also looked at incorporating the concepts of frame simulation, or incorporating our network models into frame simulation, which is certainly possible. We have also looked at incorporating other aspects such as manual control models.

Another important aspect of task network modeling is the level of detail to be used. There is no rule that says how far down you have to go in your decomposition, which is good, because that means that you can often adjust the amount of work that you have to do to the amount of time that you have available. As I indicated earlier, Task Network Models are a very common method for simulating system components. You can simulate, and we have simulated, a whole variety of system types using the Task Network Modeling approach. In fact, it is safe to say the MicroSAINT operation is used to simulate manufacturing more than human performance. Really, if you think about it any system that you can decompose into a series of activities and subactivities can be represented with a task network. That's really why it's a useful approach I think for developing integrated man-machine simulations. I think you can probably see where

TASK NETWORK MODELING

Task network modeling involves decomposing human activity into a series of discrete tasks and then defining their sequential relationships primarily through a network.

TASK NETWORK MODELING

Once a network is defined, the following additional parameters must be identified for each task:

1. **Time to perform each task**

2. **The effect the task has on other task as represented by variable manipulations**

3. **Conditions required before the task can begin**

TASK NETWORK MODELS

Additional Points

Task network models are designed to be represented in an event-driven simulation. However, they can also include continuous aspects (e.g., manual control). They can also be incorporated into frame-driven simulations.

The level of detail is entirely at the discretion of the user.

Task network modeling is also a common method for simulating other system components. Therefore, it is a useful approach for developing integrated man-machine simulations.

that's going to lead to in this talk in terms of how combat modeling might be able to use task networks. With this kind of network model and within this framework you can get, as I say, a very rigorous model of the whole system, not just the human.

MicroSAINT has gotten some interest over the past couple of years in terms of being a tool for human performance modeling, and a tool for test network modeling. MicroSAINT is a tool, not a model, per se, like the optimal control model or the AURA model. What MicroSAINT is, is a tool for developing network simulations. What I want to cover in the discussion of MicroSAINT basically is three things. One is a little bit about the philosophy behind it because that is kind of important. Second, a very quick history of the tool, and then finally I'll run through some of the computer screens.

When I started developing MicroSAINT and doing some of the early work, one of the things that occurred to me that I wanted to change in the world of computer simulation is the concept that developing computer simulations really does not need to be a black art. I have had the feeling over the years that people have made the science a lot more difficult than it needed to be. I had used computer simulation through undergraduate and graduate school, and I never thought it needed to be as complicated as it seemed to be. Why then is computer simulation and modeling still perceived to be a relatively complex process? The reason is, I believe, complex systems really can not be explored deterministically under dynamic operating conditions. I think you are seeing that in the conference here today. We are no longer talking about simple equations or simple algorithms which link combat performance to this whole host of variables in a combat environment. There are just too many things going on. So we really need simulation.

The argument I have made for a long time is that systems analysis is really a very standard procedure during system design. We really do most of the system decomposition, and I would argue that that's probably the hardest part. So what is it or what has it been that has kept computer simulation of human performance from becoming a fairly common practice? I think the answer basically is in the tools that have been available, and this is where MicroSAINT comes into it. Basically the tools that have been available have been very primitive. Up until recently if you needed to develop a simulation, what you did was call in the simulation experts, explain your problems to them, they would come back a couple weeks later and give you the simulation. That approach had a whole host of problems associated with it. For a while I wrestled with the question, "does this need to be the case?" and I came up with what I think is an appropriate metaphor, the computerized spread sheet.

Up until about 1981 only computer programmers could do financial kinds of analysis on a computer, and then Visicom appeared on the scene and then all of a sudden anybody could do financial analysis on the computer. All they had to do is understand the problem. What they did is they brought the computer capability closer to the people that had the problem. I think the same thing is true of simulation, and what we really need is a tool to bring. So with that direction, we have developed MicroSAINT. The history of the development started with an ARI project in the early 80's. I got interested in this idea of a spread sheet like modeling tool and in the mid-80's we won a contract with the Joint Working Group on Drug Dependent Degradation (JWG-D3) and Military Performance. They wanted to map the effects of drugs onto real life performance, but they didn't want to do that by going out and running tank crews off the edges of cliffs after they gave them enough drugs. So what they wanted to do was build a simulation tool, build a bridge between performance as measured in the laboratory and performance as predicted in the field. In about a year we developed a Beta test version and in late '85 we delivered version 2.0, which was the first working version of MicroSAINT. I won't go through all the iterations, but basically the tool has progressed.

I was surprised this morning to find out that MicroSAINT is being used in the Navy. It has found its way into a lot of places, which I think is good news, because it will promote the use of simulation more than we have been in the past. MicroSAINT has been specifically designed for modeling human machine systems. Even though it's applicable to other problems, it was built around the human performance problem, so I think that helps. It has been shown to be easy to learn. We are able to train people; people with no experience in simulation on how to use this thing in a couple of days.

Now, let me talk a little bit about the technology. It's a military product, so it's available to all military organizations. The technology behind it is IBM PC based, but highly portable. Under Bob Mills' sponsorship, we have ported the thing to a VAX as part of the generic systems analyst work station at Wright Patterson Air Force Base. MicroSAINT has a rather large model capacity. I don't know if it would work for these huge force on force combat models on an IBM PC, but certainly we have not run into

THE PARSER IN MICRO SAINT

An advanced software component, known as a parser has been embedded within Micro SAINT.

The parser permits the user to develop, essentially, detailed computer code within the model

- At every menu location followed by a semi-colon, a set of program statements in a C-like programming language can be included

However, this code is stored in a database and, as the simulation executes, the expressions are "parsed" and executed

Essentially, it is an embedded programming language

MANPRINT Products

- ARI Contract
- 6 Products
- Micro SAINT is the soul of 3 of the six products.

constraints in modeling human performance for small groups performing their tasks in a combat environment.

There are three basic things that you do with any model. One is you develop it; secondly, you execute the model, run it, and collect data with it, and third, you analyze the results. This is where the action is. Since it's a software tool and the focus is on usability, we have utilities for merging and organizing files. We have incorporated a capability that we call "parser." Parser essentially let's you build detailed computer code within the model. It's stored in the data base and as the simulation executes, the simulations are parsed and executed. This has turned out to be pretty handy. Now, to summarize the features; MicroSAINT has been designed for the user of simulation results rather than the simulation expert. We have really tried to bring that into the world of users. It is completely menu driven with a consistent user interface. It provides on line help, and it's easy to use by the user with little background and computer experience. We have discovered that MicroSAINT, like SAINT, which is an earlier task network modeling language) is much more powerful than it was originally anticipated. While its focus is on human performance modeling, I want to reiterate it has turned out to be a reasonably powerful tool for other types of systems.

With that I'll leave MicroSAINT and talk about two projects that we are doing using the tool. Essentially what we have done is taken MicroSAINT and built software around it. We have two contracts that I think are relevant to this situation. One is a development for the Army's MANPRINT program, and second is integration of MicroSAINT and HOS. HOS was referenced earlier as the Human Operator Simulator. HOS was a very much "bottom up" project, while MicroSAINT is top down. In MicroSAINT you build from the top and you break it down as far as you need to go. HOS started at the bottom where you had micromodels that you then had to built up. We are trying to integrate those two products so for human performance modeling you can go either way.

First let me talk about the MANPRINT program. I don't want to get into a discussion of the MANPRINT products themselves, but rather tell you how Micro SAINT is being used in the program. The important thing here is that Micro SAINT is the soul of three of the six MANPRINT products. In essence, what the MANPRINT program is trying to do is to tie manpower, personnel and training issues (MPT) to system performance. In other words, they want to know what the impact is going to be

APPROACH

To tie system performance to MPT concerns using quantitatively-oriented software tools.

To consider human performance in the context of system performance.

The focus is on tying the effects of MPT on human performance to system performance.

MANPRINT Tools

- PC - based, automated decision aids

- User-friendly
  Menu-driven
  On-line, context-specific help

- Based on computer simulation
  Allows "what-if" comparisons
  Create, execute, store, compare multiple scenarios

- Divided into two types of products
  Pre-design forecasting tools
  Design evaluation tools

MANPRINT Tools

1. System Performance & RAM Criterion Estimation Aid (SPARC)
2. Manpower Constraints Estimation Aid (M-Con)
3. Personnel Constraints Estimation Aid (P-Con)
4. Training Constraints Estimation Aid (T-Con)
5. Manpower-based System Evaluation Aid (Man-seval)
6. Personnel-based System Evaluation Aid (Per-seval)

on a system if there is not enough people to man it, if the people aren't of the right type, and if they don't receive enough training. We are under contract to the Army to develop a series of very quantitatively oriented software tools, the focus of which is to try to link MPT effects to system performance. They are all going to be microcomputer based, and user friendly.

The purpose of SPARC (System Reference & RAM Criterion Estimation Aid) is to take either a mission level requirement or a function level requirement, and decompose it down into task level requirements using a budget process. They want to make sure that all the tasks add up to the mission level requirement if you set time and accuracy requirement at the mission level. They don't want to design a bunch of tasks that aren't going to allow you to meet system requirements. The second, third and fourth products shown in the above figure I am not going to talk about here. Essentially they play a zero sum game with numbers of people, types of people and amount of training. You set constraints about how much training, what type of people, etc.. Then the fifth and sixth products are post design tools. I think the important thing is to see how these things all fit. The post design tools are what you use to see if the requirements that you initially defined were met after the system was completed.

Let me just make a point through showing you the process of how these things are supposed to fit into the system's acquisition process. The whole system's acquisition was supposed to be driven by mission area analysis. Amongst the things that go into the mission area analysis are the combat model results. The combat model is presumably what tells you that you have got a threat out there that hasn't been dealt with effectively and we have got to do something about it. The analysis should tell us we have got to design a system that's faster or more accurate or whatever it is to meet the threat.

Now, there are three things I want to bring up with respect to the MANPRINT project. First of all, as far as I know, this is one of the first serious attempts at linking the combat modeling process with system development. The combat modeling process drives everything we do all the way through to the end of the system design. At every point in the development, designs are always evaluated against the simulation model requirements. The second thing is that we have tried to embed performance shaping functions in some of these products. We are trying to include some of the stressors associated with MOPP and sleep deprivation, as well as personal characteristics. The third thing about the MANPRINT program is that as part of the project we are developing some very extensive combat simulation data libraries. We have test network models that incorporate human performance models for 20 plus Army systems. This library of models will allow researchers to build, modify and refine existing systems as new human performance information is developed.

Our second major piece of related work is the MicroSAINT HOS integration. HOS really works from the bottom up, where you have a rather detailed model of basic activities such as decision making for hand movement. If you compare that to MicroSAINT where you start out with the individual task level, you kind of see where those two things can meet in the middle. In the ideal environment, what will happen is MicroSAINT or the task network model will be the overall software driver, and from that you will call a function library, which will bring in and let you build up the performance time estimates and performance accuracy estimates using some of these human performance micro-models. This will allow you to develop the overall task performance estimates. That pretty much concludes our ongoing work.

I would now like to talk a bit about how I think the task networking model can be used to incorporate human performance variability into combat models. The key part of the phrase here is that we really want to incorporate human performance variability We don't really need to include detailed human performance in all combat situations, but by not putting any model in there to represent variability of the human associated with whatever elements of the battlefield are going to affect his performance (as Dr. Kolpcic indicated) assumed a model value of one.

I certainly don't want to make the case that we need to get down there in the severe details of things. In fact, I have a fear that when people think of human performance modeling and combat models, they think of what I call the "blue socks syndrome," which is an idea given to me by a modeler. He indicated that he would go out to a manufacturing facility and develop what he thought was a very good model, covering everything he needed to cover. He would take it in to the manager and show him the model, and the manager would say, "Yeah, but what happens if the guy wears blue socks?" Somehow my modeler friend didn't think that was very important. I don't think that's very important either and I don't think we are going to be modeling guys in the battlefield wearing blue socks, and that we shouldn't get down to that level of detail.

What we need to concentrate on are those things that affect human performance as they relate to a particular modeling application. Let's get those in the models. Let's incorporate those aspects of variability that make a difference. As I see it there are three ways of using task network modeling in combat models. First, we can decompose human tasks within a combat model into more finely detailed task networks. Second, we can develop performance shaping functions for relating performance to other variables, primarily combat stressors. Third you can develop the task network models as independent stand alone modules, or as integral parts of the overall model. All three of these are independent of one another. You can take these in any kind of combination that you need.

Summary points: Task network analysis provides a basic framework and a bridge for incorporating human performance variability into combat simulation.
There is existing simulation software to make incorporating human performance data feasible. There are at least three approaches for incorporating human performance variability into combat models: Decompose human task with the model; develop performance shaping functions; and conduct human performance simulation external to the combat simulation model. Bottom line is that there probably is not a right approach to cover all questions. It really depends on the combat model involved. For some levels, we may want to do one thing, and for other levels we may want to use another approach. There is not going to be a single answer.

APPLYING THE CONCEPTS OF TASK NETWORK MODELING TO INCORPORATING HUMAN PERFORMANCE VARIABILITY INTO COMBAT MODELS

Key part of that phrase is "incorporating human performance variability."

- **We don't need to include detailed human performance models in all combat simulations, but we should strive to represent the variability of human performance in these models as it will significantly affect the outcome.**

ALTERNATIVE WAYS OF INCORPORATING HUMAN PERFORMANCE VARIABILITY INTO COMBAT MODELS FROM THE PERSPECTIVE OF TASK NETWORK MODELING

Three basic sets of alternatives:

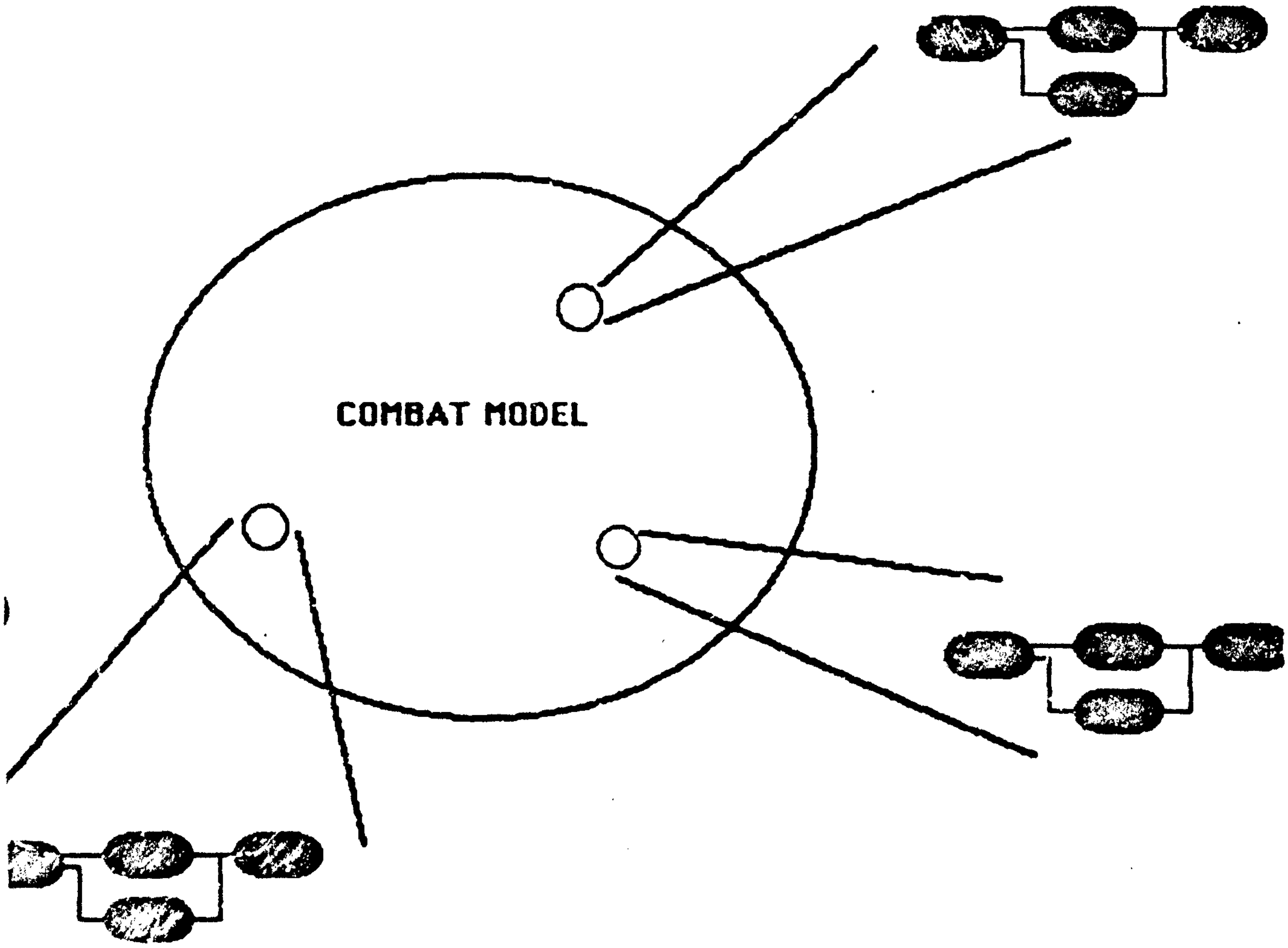
1. **Decompose human tasks within a combat model into more finely detailed task networks**

2. **Develop performance shaping functions for tasks within combat models relating performance to other variables of interest (e.g., combat stressors)**

3. **Conduct human performance simulations external to the combat model and set combat model parameters reflecting the outcomes of these simulations.**

All three of these are independent of one another

DEVELOP DETAILED TASK NETWORKS



SUMMARY

- Task network modeling provides a basic framework for incorporating human performance variability into combat simulation

- Existing simulation software, such as Micro SAINT, make the incorporation of task network modeling more feasible

- Within this framework, there are at least three approaches that can be included singularly or in combination

- The right approach will depend upon the questions being addressed by the combat model - there is no single answer.

MR. BANKS: Thank you. Before I introduce the next speaker, I would like to mention a new technology called Intelligent Gateway Processing (IGP). What this technology allows one to do is to talk with any computer regardless of its architecture, operating system or physical location. That sounds like a rather big statement, but in fact it's true. One of the problems we have seen in the Navy and the Air Force is that they are forced to procure lots of different types of machines, and these machines are not easily interconnectable. These machines don't talk to each other. For example, it is difficult for a Hewlett Packard to talk to a Data General, and it is difficult for a Data General to talk to an IBM, etc..

What a Gateway essentially allows one to do is sit in your office and hook up to 150 different computers. It's a table driven interpreter that stores all the protocols of all the other host machines that you wish to talk to. Through the interpreter you talk in your language for your PC and it converts it to the target host that you are trying to connect to. So you don't have to know the system's command language of the down line host. What this has an implication for is remote combat simulation modeling. I can have a model here at Livermore and give access to it to the Army, Navy, Marine Corps, TRW, and General Electric without their physically having to have that hardware and software running at their site.

Another scenario; let's say you are sending troops on a combat mission. Weather changes, enemy strength changes because of new updated intelligence. You could play the game on a C-130 as you are flying into the combat zone. You could actually go through one last review of the operation before you come in. That's real time combat simulation modeling.

The reason I am mentioning it to you is that over the break I realized that a lot of people were not aware of the IGP technology. It's about five years old; the Air Force has embraced it, the Air Force Logistics Command now has installed 31 Gateways. NASA has installed 14, and a few other government agencies have ordered them.

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SHIPDAM

SHIP DAMAGE MODEL

JACK HAWKINS
DTRC

DTRC
DAVID TAYLOR RESEARCH CENTER

DTNSRDC

NSRDC

DTMB

EMB

NAVY'S HM&E LAB

ADDRESS BY MR. JACK HAWKINS

MR. HAWKINS: I'm going to talk about SHIPDAM (Ship Damage Model), a model that the Navy has been using for the last two or three years. It's not fully documented yet and probably won't be for a while, but it's a simple vulnerability model for surface ships.

I am from David Taylor Research Center. We are a Navy lab. We are what used to be called the David Taylor Model Basin. I work in the structures department at David Taylor, and my division's work is primarily in surface ship vulnerability.

The main tools that we use have been developed over the last 15 or 20 years and include the Ship Vulnerability Model (SVM), and the Soviet Ship Vulnerability Model (SSVP). Ship vulnerability model is for U. S. ships attacked by Soviet weapons. The soviet ship model is just the opposite. To give you a little picture of what goes into the SVM before I get into SHIPDAM, I have included the following figure. There is a lot of input. The ship is described in great detail, plate by plate almost, and components are modeled, in some cases down to consoles in various compartments.

We combine the vital components to form systems, we combine systems to form mission areas, and combine mission areas to perform overall readiness approximations. The attack parameters of Soviet weapons are input using whatever intelligence data we can get. The physics that's gone into the damage mechanisms is based on World War II data, what we derived from war damage reports. Much of it is theoretical. The output finally is the effect on the system readiness and vital components as a function of number of hits. When we use this model we do a large number of trials, a Monte Carlo assessment.

The next figure is an example of how the vital components are connected in order to build a system. In this case you will notice everything that's in series is vital. If any one of those go down, the system is considered down. The two motor generator sets are in parallel, so you would have to lose both of those to lose the function of that mission.

The next figure deals with the C3 function. I think probably most of you all are familiar with the C3 readiness designation. That roughly equates to 50% performance of the ship in its mission areas, and we use the system descriptions to form a C3 diagram. Anything linked in series is vital. A representation of how the hit distributions for these

STRUCTURES DEPARTMENT
SURFACE SHIP PROTECTION DIVISION

- SURVIVABILITY/VULNERABILITY
- U.S. & SOVIET SHIPS & WEAPONS
- PROTECTION DESIGN
  - ARMOR
  - ARRANGEMENTS
  - ETC

SVM

SHIP VULNERABILITY MODEL

&

SSVP

SOVIET SHIP VULNERABILITY PROGRAM

weapons is input to the SVM is shown in the next figure. This is critical stuff and this is what we know the least about. I'll get into that after a while. As I said, it's a Monte Carlo technique. We run a lot of trials, with a number of iterations, and come up with expected values.

This next figure shows a little bit of how the results would look. This is typical, but not representative of any particular ship. As you can see, we have the number of hits, and the probability of a mass detonation, which is an important event in our assessments, because it generally results in the ship sinking and then the effect on various mission areas, and these are combined to determine overall readiness in the last two columns.

The next figure shows a few of the recent applications that SVM has been used for. This includes SSVP applications as well. The cost of SVM is very high. It takes a long time to model a ship in the required detail, and it takes a long time to run the program to get the results. The SVM is an engineering design tool, and it's appropriate that it should be detailed, but it proves not to be especially appropriate for war gamers to use, particularly the Center for Naval Wargaming (CNW) up at Newport. The people at CNW came to us and asked us to make a short version of SVM, something they could use on line perhaps, that would give them answers to provide the players with when hits occur on ships during the war games.

The difficulties that they found with models that we had traditionally used was that they had to rely on look up tables rather than being able to go in and take the damage of a particular hit at a particular time. The data bases were incomplete. We haven't modeled every ship at the level of detail required by those two bigger tools, and they are inconsistent. The SSV, SVM and SSVP won't produce the same answers because they are not designed to evaluate the same way. We have a conservative bias in each of these models.

For the SVM we are conservative on the side of protecting the ship, for the SSVP we are conservative in that we are designing weapons to defeat Soviet ships. So the two models (if they were used on the same ship) would produce different results. That wasn't right for the war games. They wanted a totally consistent data base. Maybe not as detailed, maybe not as precise, but at least evaluating each size ship to the same set of standards. The SVM, because of the large number of runs we do, can't do weapon mixes. In a war game you can get hit by a torpedo and then by a missile, and there would be no way to run the SVM enough times to produce those sort of values.

Because of these programs CNW funded development of SHIPDAM. SHIPDAM is based on the SVM and SSVP practices. What I did was to simplify all the descriptions and the algorithms and tuned it as I simplified the algorithms. I ran SHIPDAM a number of times and compare it to a similar run in the bigger model. I tuned its results to get within 15% to 20% of the big model. We know that the externals of the ship pretty much define what the internals are. Ship design hasn't changed a whole lot. You can make a lot of assumptions that are going to be pretty close to right just by looking at the outside of the ship.

In the simulation at CNW the users generate weapon hits against particular ships. The users can indicate where they hit the ship. They may or may not generate the first point. If they don't, we have included in SHIPDAM the ability to apply those hit distributions that we use in the bigger models and come up with the impact generator for their use.

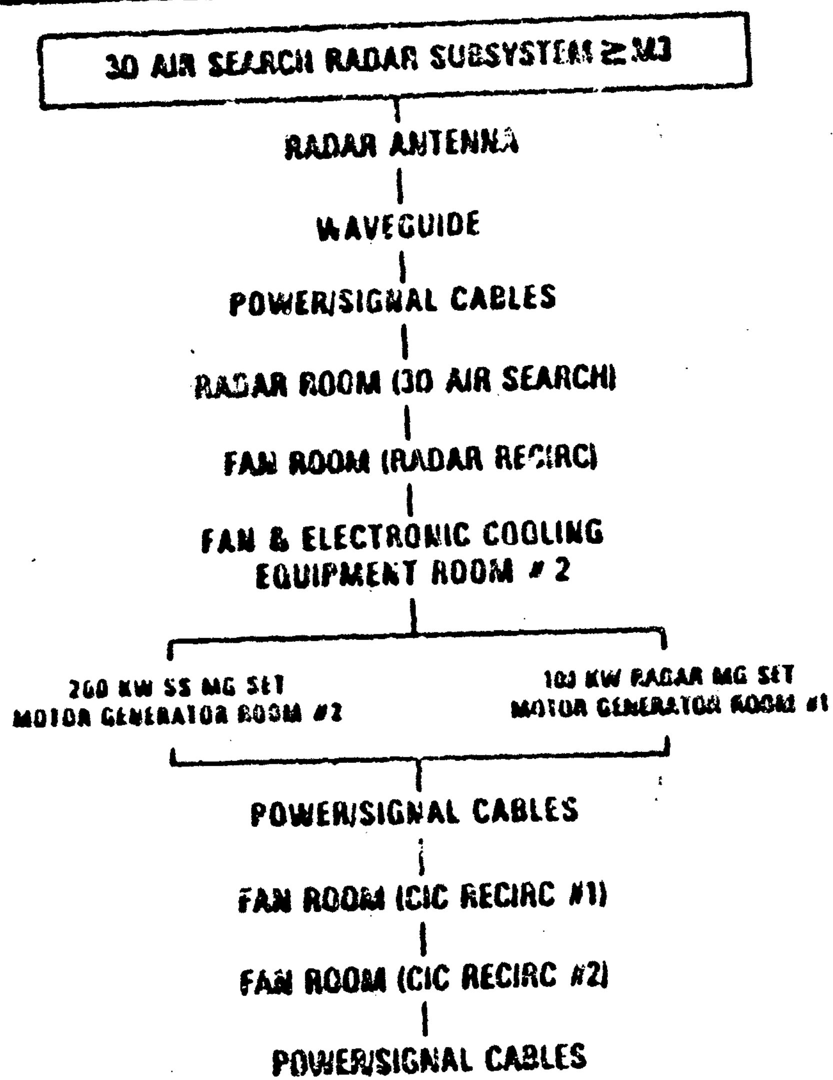
The output of SHIPDAM is whether or not the ship is sunk, what weapon systems work, how the mobility of the ship is affected after the hit, and how much flooding has occurred.

I'll quickly go through what SHIPDAM looks like. It consists of four parts: the burst point generator (BPG), a weapon data file (WEP), the BDA which is the ship description data, and SHIPDAM algorithms.

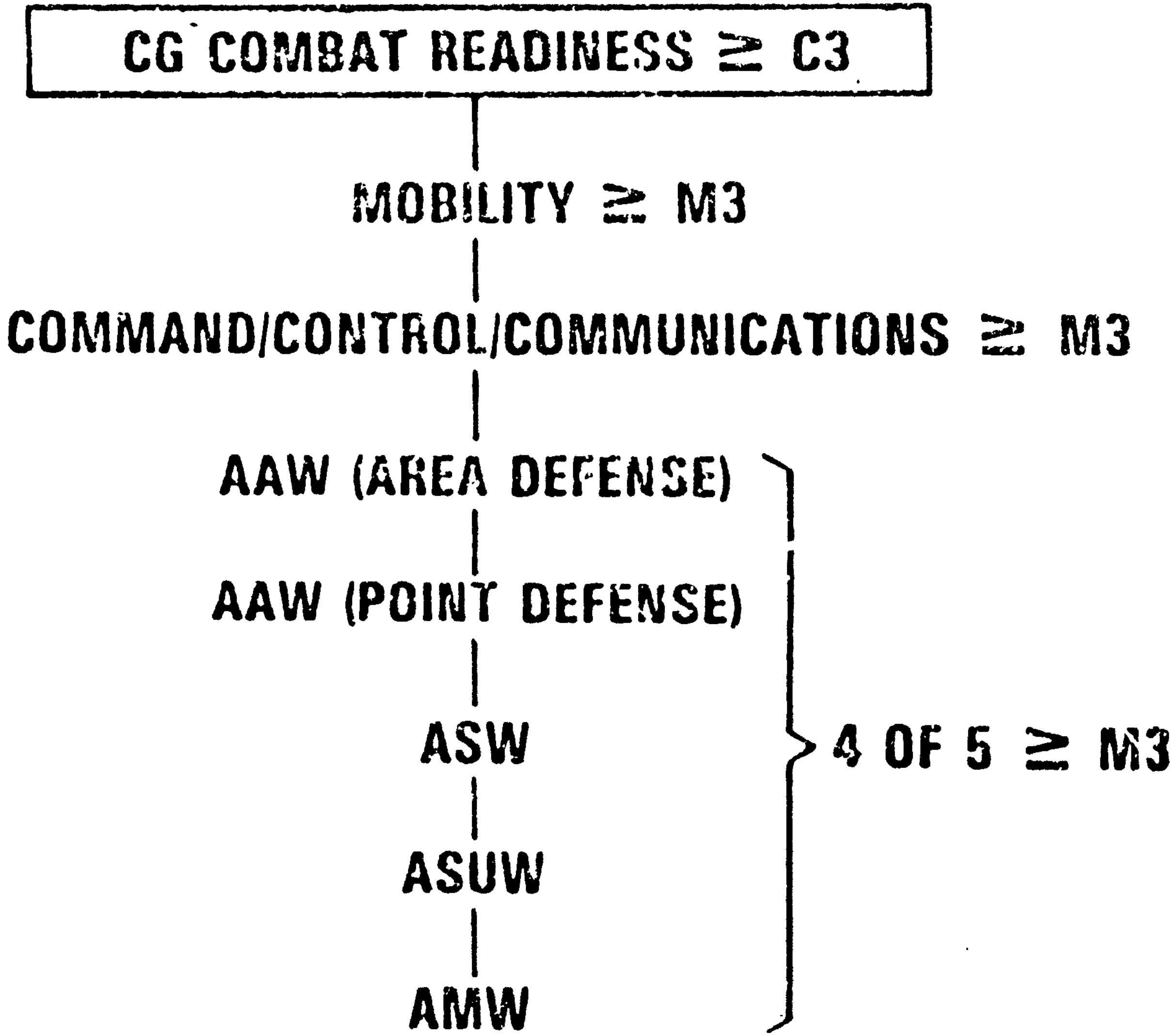
(1) The BPG is a very simplified structural geometric representation of the ship. All it's there for is to tell the weapon that it's encountered the ship so the weapon knows what it's dealing with. Included in it are aim points for the various guidance systems that are part of the weapons data base.

(2) Weapons (WEP) input, is also a very short file. As shown in the next figure, it consists of two simulation symbols, the azimuth and elevation angle of attack for the particular weapon. We also include the velocity, type of weapon, whether it's a missile or torpedo, guidance, the fusing delay or proximity, a couple of sequences related to hit distribution if we know enough to include one of those, and its SAB or delayed action fuse.

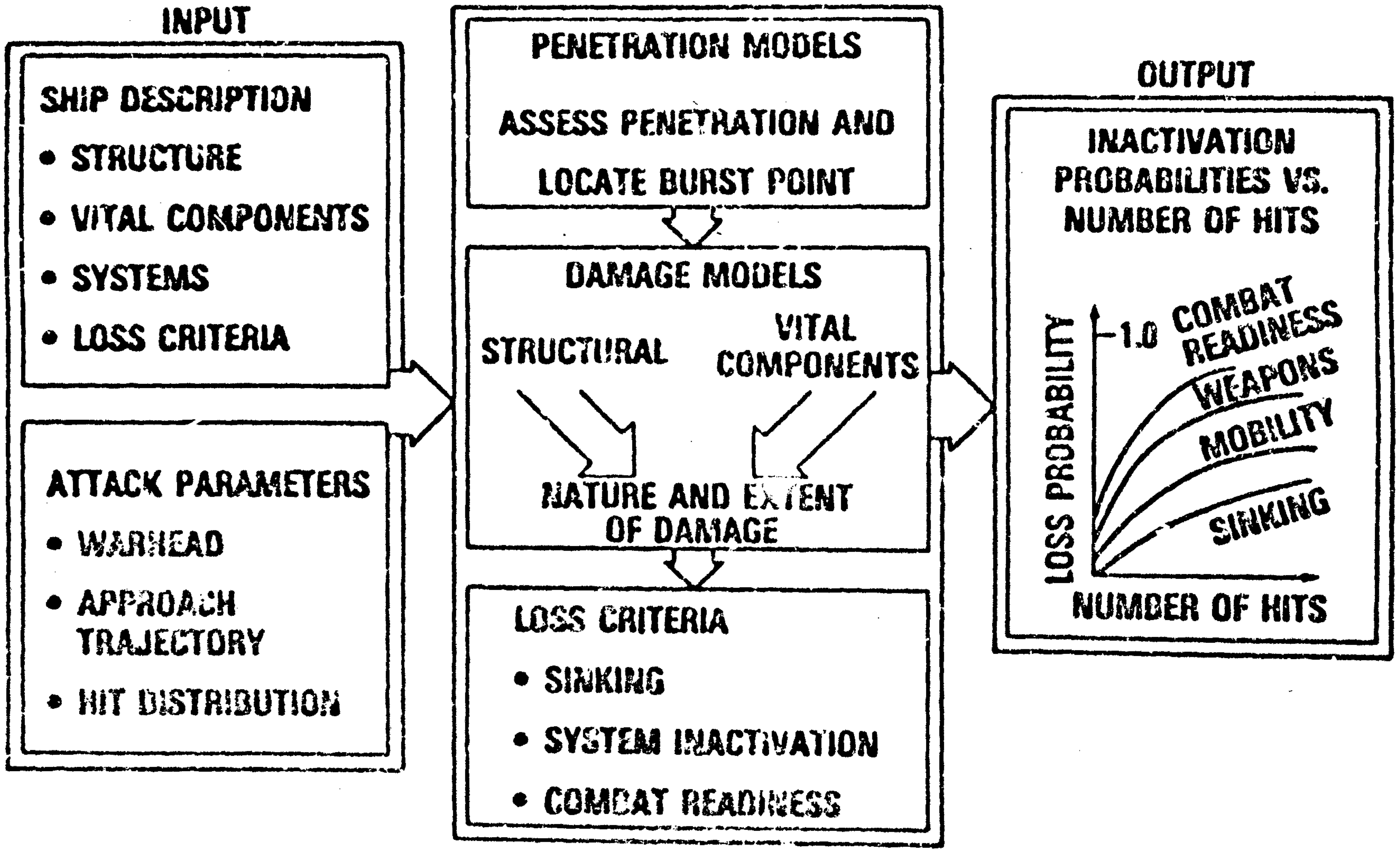
EXAMPLE SUBSYSTEM OUT-OF-ACTION DIAGRAM



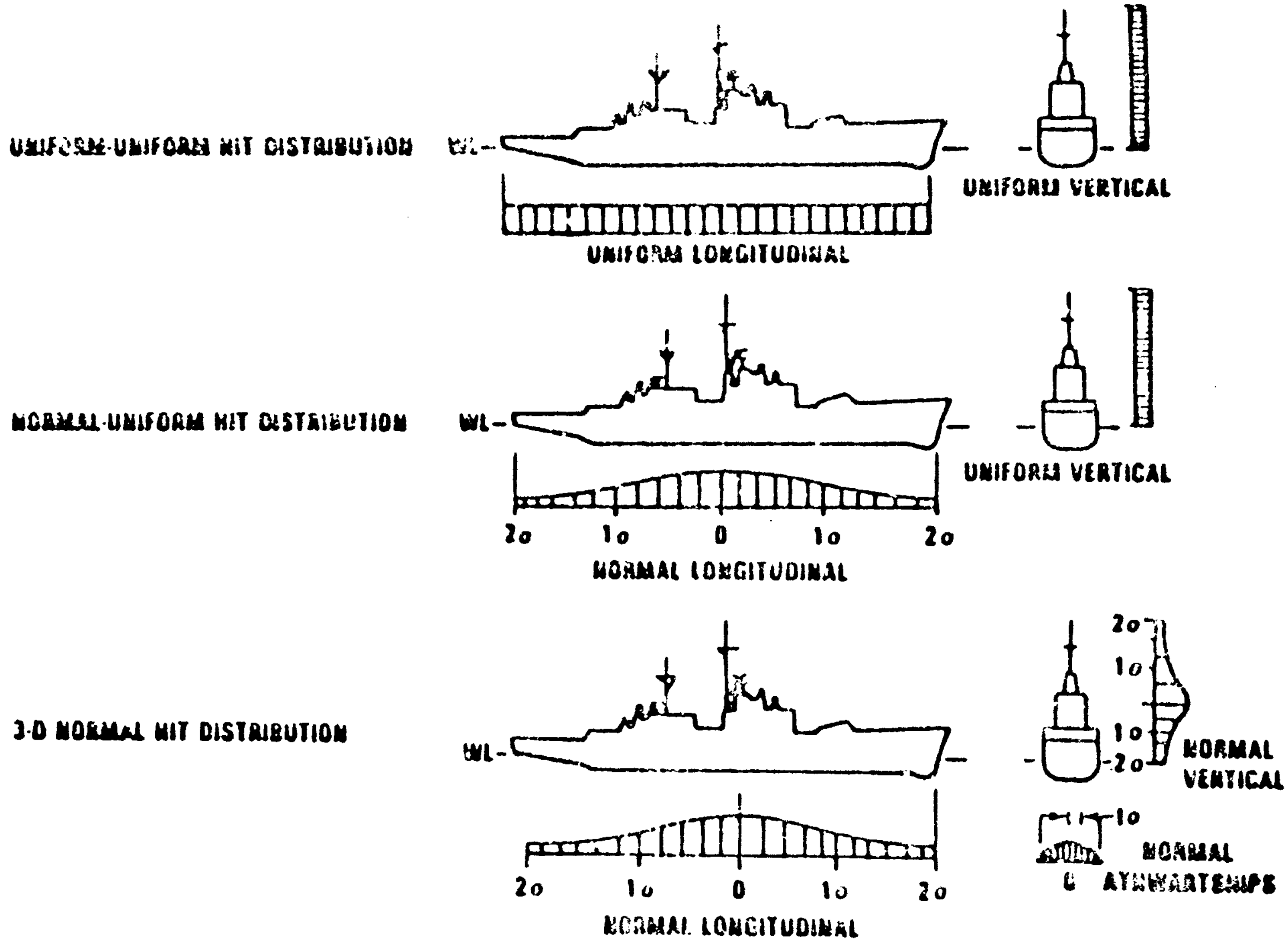
EXAMPLE C3 OVERALL COMBAT READINESS OUT-OF-ACTION DIAGRAM



SHIP VULNERABILITY MODEL (SVM)



ATTACK HIT DISTRIBUTIONS



OUT-OF-ACTION PROBABILITIES BY MONTE CARLO PROCEDURE

$$P = \frac{\text{NO. OF TRIALS IN WHICH OUT-OF-ACTION OCCURRED}}{\text{TOTAL NO. OF TRIALS}}$$

TYPICAL SVM OUT-OF-ACTION PROBABILITY TABLE

MISSION AREA

HIT NUMBER	MASS DETONATION	SINKING	AAW (POINT DEFENSE)	AAW (AREA DEFENSE)	AMW	CCC	MOBILITY	ASW	ASW (W/O ASW HELO)	ASUW	COMBAT READINESS	COMBAT READINESS (W/O ASW HELO)
	A	B	403	410	500	501	502	503	504	505	506	507
1 –	0.00	0.00	.92	.66	.83	.91	.28	.81	.80	.90	.55	.54
2 –	0.00	0.00	1.00	1.00	.93	.99	.60	.86	.86	.90	1.00	1.00
3 –	0.00	0.00	1.00	1.00	1.00	1.00	.64	1.00	1.00	1.00	1.00	1.00

RECENT SVM APPLICATIONS

- SHIP DESIGN
  - ALL COMBATANT TYPES - BACKFIT AND NEW DESIGN, INCLUDING ADVANCED TYPES
- WEAPON DEVELOPMENT
  - HARPOON, TOMAHAWK, 8" GP, CONDOR, MRASM (TOMAHAWK 2), MAVERICK
- WEAPON EFFECTIVENESS DATA
  - BOMBS, HARPOON, WALLEYE, LGBs, TOMAHAWK
- NET TECHNOLOGY ASSESSMENT
  - RELATIVE VULNERABILITY OF U.S. AND SOVIET SHIPS
- SENSITIVITY STUDIES
  - FUSE DELAY, BLAST DAMAGE, SHOCK DAMAGE, MASS DETONATION, SEAWORTHINESS, VC LOCATIONS, ELECTRIC WIRING, FIRE SPREAD, PROTECTION FEATURES, STATISTICAL

COST OF SVM-BASED VULNERABILITY ANALYSES

- PREPARATION OF INPUT
  - SIMPLE TARGET DESCRIPTION—3 MAN-WEEKS
  - COMPLEX/DETAILED TARGET DESCRIPTION—6 MAN-MONTHS
- COMPUTER RUNS
  - TYPICAL RUNNING TIME—2 HRS (ONE WEAPON, 3 HITS, 100 TRIALS ON CDC 6000 SERIES)

SVM & SSVP PROBABILITIES

- LOOK-UP TABLES
- OFF-LINE
- INCOMPLETE DATA BASE
- INCONSISTENT DATA BASE
- ANOMALIES
- THREAT WEAPON MIX

SHIPDAM
(FORMERLY BDA)

- SVM-SSVP BASED
- SHIP DESCRIPTION SIMPLIFIED
- WEAPONS DESCRIPTION SIMPLIFIED
- DAMAGE ALGORITHMS SIMPLIFIED
- "TUNED" TO APPROXIMATE SVM - SSVP RESULTS
- UNCLASSIFIED BY NECESSITY AND SIMPLICITY

(3) The BDA program tells us what algorithms to apply for that weapon, the charge weight, and if it's a jet weapon. If it is a jet weapon, put in a jet length and diameter. I don't try to model the interaction of the jet with the ship's structure. For most ships and most large jet weapons, it will just penetrate clean through. The BDA file is the file that contains each of the vital zones. I don't model vital components in the same way the SVM does. I model a zone in a ship. For instance, a radar system in my model will just be an antenna, a wave guidance is a simple volume. A wave guide and a volume of space roughly under that mast will be approximately the same volume as the radar room, the associated fan room, or whatever electronic cooling rooms might have been associated with that antenna.

(4) The SHIPDAM projects being worked on now are an attempt to include personnel casualties in the model, and hopefully to provide something for the war college that will tell them how long after they take damage to the systems it will take to get them back up. That has become a pretty big question when they are doing the games. There is an outfit in Philadelphia called NAVSHIPS that tabulates the manufacturing lead times and availability of parts, and I think we can connect that and have values on each vital component, that will give a rough indication of how long it would take to replace them.

SHIPDAM has never been placed on line at Newport. I think the new system of war gaming that they have been developing and hoping that SHIPDAM would integrate with hasn't reached the development phase that they had hoped for. They currently use SHIPDAM off line, and it seems to have satisfied their needs for now. The model is still very visible. When a carrier sinks, Admirals show up at the SHIPDAM desk and ask about it.

The model is still developmental, and I am adding things to it all the time. This is a nice feature. The model is very flexible and easily changed. SHIPDAM hasn't been documented and that's been intentional. As soon as I document it, people will start using it, and since I am developing it, I don't want people to use it unless I know about it. I have never held it out to be accurate. I started off telling people it would be ancillary, and they seemed satisfied with that.

INPUT (FROM GAME PLAY)

= TARGET SHIP
THREAT WEAPON
BURST POINT

OUTPUT

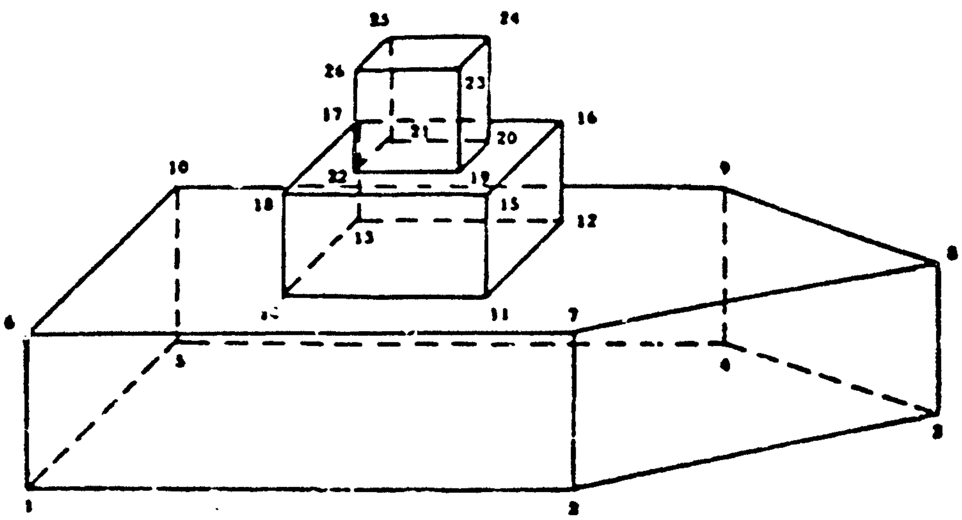
= SHIP SUNK (YES OR NO)
MOBILITY (100%, 50%, 0%)
SYSTEMS INACTIVATED :
SPS-49
HARPOON
SLQ-32

SHIPDAM FILES

- BPG - Burst Point Generator
- WEP - Weapon Data
- BDA - Ship Description Data
- SHIPDAM - Simplified Damage Algorithms

.BPG

INPUT - VERTICES:



AIMPOINTS:

GUIDANCE	X	Y	Z
RF	120	23	41
ARM	130	23	36
IR	.	.	.
..	.	.	.

.WEP

INPUT :

θ, α
VELOCITY
TYPE, GUIDANCE, FUZING
σ_X, σ_Y
DELAY
BDA TYPE, C_s WT, JET L, D

I got interested in modeling casualties because at some of the war games I observed I saw people that were assessing casualties during the games. They had some tables of killed and wounded by ship class, but didn't have it by weapon class. The information they were using was a rather crude estimation made from World War II data, but it was very incomplete. Their tables didn't respond to the particular weapon, they didn't respond to the particular ships, and they only included large ship classes. It seemed that since we already had the ship modeled and we already had the compartments on the ships modeled, it would be fairly simple to include people. If I didn't take them too seriously and if I treated them like a piece of equipment, they should fit right into the SHIPDAM model. It seems very straightforward.

At David Taylor we had background in personnel protection. I asked Naval Medical R&D for funding, and received 5K to do a quick feasibility study. I used an FFG-7 since that's a simple ship and made some very simple algorithms that I got out of readily available data, and then did hand calculations on an under bottom threat and a big missile threat, and the numbers came out looking reasonable at that time. Nothing much happened for a while after that. Then the Stark and the Roberts events occurred and they checked how SHIPDAM did, both for the equipment damage and for personnel killed and wounded, and again, it did reasonably well. It wasn't terribly good on the personnel.

On the Stark the people were not where they were supposed to be. On the Roberts, my algorithms were not as good as I would have liked, and the damage control officer on the Roberts had done a better job than Navy specs called for. He got his people in a better readiness condition than one would have ever guessed. But the results did match up reasonably well, well enough to encourage some of the people in the Pentagon to look at the model a bit more. In March of this year, the Navy got concerned about its casualty rates. They decided that they needed a new set of casualty rates, one that would be auditable. They were ready to go out with an RFP to private industry. It became pretty clear that for at least the Navy afloat, whoever got the contract would have to come to the model bases to get ship damage assessment, and if we were going to be imposed on that much, we might as well go ahead and take on the job. So we did.

The program calls for developing casualty statistics for four categories of Naval personnel: Personnel afloat, personnel ashore in fixed facilities, personnel ashore mobile, and personnel with the Marines. They wanted four values: killed in action, wounded in action, missing-in-action and diseased non-vital injury. We have subsequently added a new category for the Marines on Navy ships. The Marines didn't account for them and neither did the Navy. Our approach has been to document what has been done previously and to develop some new values where appropriate. For most of the needed numbers we are not the appropriate facility to develop them. We are appropriate for naval personnel afloat, but for everything else we have had to identify other organizations where the information is available.

A lot has already been done and all we have to do is bring it together. Bill Pugh at NHRC has been working with DNBI data. He has been funded and just completed that work. The Marine Corps has just gone out with a contract to update their values, and we will use their values for Navy personnel with the Marine Corps.

For the ashore fixed site, two organizations have been identified so far. The Air Force has asked their contractor (BDM) to prepare casualty rates for Air Force bases. The Naval Civil Engineering Lab at Port Hueneme has a model that seems to be fairly similar to SHIPDAM, only it models structures rather than ships. The Navy ashore model is a catch-all; about 10 or 12 different constituencies involved that don't have very much relationship to each other. We will probably end up using data from the Army or the USMC.

Our procedures assume that personnel are manning their general quarters stations. That's where we went wrong on the Stark. Aboard the Stark, nobody was at general quarters when the ship was hit. Most people on a ship at general quarters are standing inside what I have previously modeled as vital zones. They are standing around equipment that's necessary to make the ship work. The only personnel that we need to add additional locations for are the damage control parties. That's important. They are usually located in corridors or passageways away from the vital components currently in the model. With a minimum addition of vital zones, we can account for virtually all the people on board.

I have put in some injury algorithms and we are working to improve them now. Since SHIPDAM runs very quickly, I will be able to run any ship class against any weapon type a large number of times in a few minutes and get expected numbers of killed and wounded. The next figure shows you what the casualty data looks like. I can do this for each ship class and each primary weapon threat type.

ONGOING DEVELOPMENT

- Personnel - Casualties (Killed and Wounded) Based on Manning Document Location of Personnel and Shock & Blast
- Battle Damage Repair- Times to Acquire and Replace/Install Equipment, and Repair Facility Required - NAVSHIPSO, Phila., is Preparing Data to be entered into SHIPDAM

SHIPDAM

- NEVER PLACED 'ON-LINE' AT WAR GAMES
- USED AS OFF-LINE PC MODEL BY GAME UMPIRES
- VERY VISIBLE
- STILL DEVELOPMENTAL
- FLEXIBLE ENOUGH TO RESPOND TO NEW REQUESTS
- NOT FORMALLY DOCUMENTED
- NEVER HELD OUT AS MORE 'ACCURATE' THAN 'REASONABLE'

SHIPDAM & CASUALTIES

- DIFFICULTIES WITH CASUALTIES AT WAR GAMES
- PERSONNEL NOT THAT DIFFERENT THAN EQUIPMENT
- WEAPON EFFECTS AND SHIPBOARD LOCATIONS ALREADY IN PLACE
- DTRC HAS BACKGROUND IN PERSONNEL PROTECTION
- SEEMED STRAIGHT FORWARD

EVOLUTION

- MARCH 87
  - $ 5K FEASIBILITY
  - FFG-7
  - SIMPLE ALGORITHMS
  - HAND CALCULATION
- USS STARK
  USS SAMUEL B ROBERTS
- MARCH 88
  - OP-813 (OP 932, OP 601)
  - NAVY CASUALTY RATES
  - CONTRACTOR TO NAVY

PROBLEM STATEMENT

CURRENT NAVY METHODS FOR ESTIMATING CASUALTY RATES:

A. WERE NOT SUFFICIENTLY DOCUMENTED AND AUDITABLE

B. DO NOT SATISFY THE NEEDS OF ALL POTENTIAL USERS

C. DO NOT ALLOW FLEXIBILITY FOR ALTERNATIVE THEATERS OR NEW WEAPONS, TACTICS, AND TARGETS

APPROACH

- DOCUMENT TO THE EXTENT POSSIBLE THE EXISTING CASUALTY RATES
- DEVELOP NEW METHODS FOR PREDICTING CASUALTY RATES AS NEEDED
  1) DOCUMENTED, AUDITABLE TRAIL
  2) FLEXIBLE
  3) SERVE WIDE VARIETY OF USERS
- IDENTIFY AND/OR COORDINATE THE PROPER APPROACH FOR PREDICTING RATES FOR:
  1) DISEASE NON-BATTLE INJURIES
  2) FORCES ASHORE
  3) FORCES WITH MARINES
- DAVID TAYLOR RESEARCH CENTER (DTRC) WILL DEVELOP METHODS FOR ESTIMATING CASUALTY RATES

CASUALTY RATES

DNBI = MR. BILL PUGH NHRC

W/USMC = USMC

ASHORE (FIXED SITE) = AF (BDM) OR
NCEL

ASHORE (MOBILE) = ARMY OR USMC

AFLOAT = DTRC

NEW MARINES W/
NAVY AFLOAT = DTRC

There are some severe shortcomings in SHIPDAM. We don't have a fire model in it, and we don't even have a very good fire model in SDM. We have been working on this problem, but the number of variables is fairly large which makes the problem rather difficult. We are approaching this problem more from a historical viewpoint. We are going through the JAG reports and the Navy Safety Center results, trying to get a feel for how much additional damage is caused by fire.

The algorithms for human casualties as a result of smoke and fire are different than our normal algorithms for equipment; the equipment is fixed. The personnel have the option of getting out of the way of a lot of smoke and fire. I am not sure how that's going to work yet.

Our previous work concentrated primarily on mission capability of the ship, and that if it lost its mission capability and sunk, that was that. Now we have included the impact of actually sinking. For casualties it matters how quickly it sinks, it matters what sort of water it sinks in, and it matters how bad the damage was.

The Navy planning procedures call for information on when someone becomes an inpatient. This requires that we modify our classification of a casualty. We will need to use a step function. The individual is either out there working and doing his job, or he is an inpatient. We have to adjust the algorithms a little and make sure that people go into the medical facilities before they are counted.

One correction we are working on involves the location of people in the vital zones. I have been putting as many people as are in that vital zone at the centroid of the vital zone. That's fine if there are one or two guys in there, but if it's a big zone and there are a lot of people I have to go back and spread them out. I am getting inappropriate results because of that.

There are some other initiatives that are upcoming on SHIPDAM. I have told you about the "time to repair" algorithm we are working on. It's also been requested that we put in a measure of structural damage. Up until now we have just been doing mission damage. We are also going to try to use the SHIPDAM model to prioritize the prepositioning of battle spares because it's quick and easy. We are also going to try to model system reliability and human performance. I have never seen any of the war games where reliability has even been considered, and I am going to try to include a column in my vital component data that gives a measure of reliability of systems.

Human performance seems very analogous to systems reliability, so we are going to try to simulate it also. The current way we model with no reliability degradation is unrealistic.

I would like to make a few final comments about modeling generally because of my experience with this. I have seen in the SVM a design tool that has become terribly complex. It results in terribly complex solutions. The people who make these sorts of models become advocates of their models. They become really enamored with making the models perfect, or as near perfect as they can. The models become increasingly complex. There is a tendency to not want to take a chance of not including something, so you include everything.

Validation is almost impossible on these sorts of models because you can not do experimentation. You have got to try to bend historical data that was not meant to validate the model. There is constant change and growth in the model, and ultimately it gets to where it's too big. It's so big that the user can't use it.

It's not necessarily a good thing to have a model be totally universal. If you are going to use it in a small area, it only needs to be good in that small area. The SVM for a long time became very unresponsive. People would ask questions and by the time we could answer, they didn't care.

SHIPDAM allows them to get a quick answer, and it also serves as a pretty nice preprocessor for the SVM. If you have a hard question that might require looking at 15 or more alternatives to find to one or two you need, you might consider using a small program like SHIPDAM. It can do the preprocessing for you so that your detailed modeling can be concentrated on detailed problems that are appropriate for them.

MR. BANKS: Have you noticed something implicit in all these presentations, virtually all? Janus, TWSEAS, some of the other models assume that people are perfect. Does that come across to you? It has to me. We make assumptions that the center of the universe is the weapon, not the person who has to manage it. We model that weapon very well; its trajectory, its fire rate, cycling rate of fire, pounds per square inch, all of the physical attributes. But the assumption is that people don't make mistakes.

I was talking to some of my Marine colleagues and I said, (this was a couple of months ago) if I send ten squads out in Vietnam, how many squads are going to know where they are after let's say four hours, five hours? What percentage of the squads will report their correct position back to headquarters? I have a pretty good idea what that is, and it's far from 100%. It's nowhere near it. It's far from 90%. It varies anywhere from 80% for a good squad to 50%. But most of the models, at least the ones that I have seen, assume the individual will not make a mistake.

SHIPDAM CASUALTIES PROCEDURE

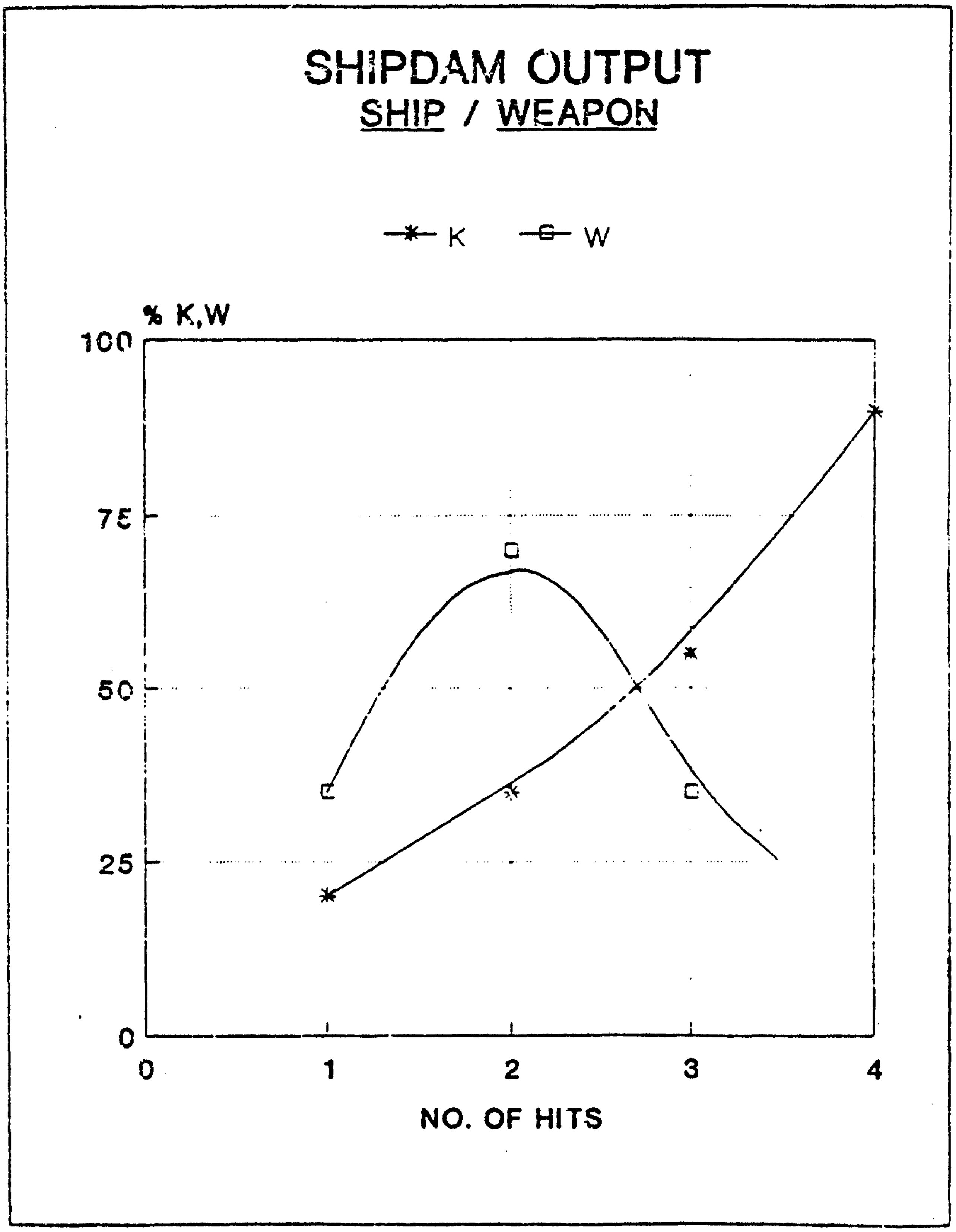
- LOCATE PERSONNEL AT GQ STATIONS
- ADD LOCATIONS IF NECESSARY
- INCORPORATE INJURY ALGORITHMS
- ASSESS EFFECTS OF LARGE NUMBER OF HITS & TRIALS FOR EACH SHIP CLASS & WEAPON COMBINATION
- OUTPUT IN TERMS OF EXPECTED KILLED & WOUNDED AS A FUNCTION OF SHIP, WEAPON, NUMBER OF HITS

PERSONNEL LOCATIONS

- SHIP MANNING DOCUMENTS (GENERAL QUARTERS)

ALGORITHMS

- SHOCK (UNDERWATER EXPLOSIONS) FROM DTRC, NBDL WORK
- OVER-PRESSURE (AIR BLAST) FROM ARMY LITERATURE
- OVER-PRESSURE/BLAST (INTERNAL EXPLOSION) FROM SSVP/SVM OVER-PRESSURE TRANSLATIONS


SHIPDAM OUTPUT
SHIP / WEAPON
K
W
% K,W
100
75
50
25
0
0
1
2
3
4
NO. OF HITS

SHIPDAM - CASUALTIES
MAJOR PROBLEMS

- FIRE MODEL
- FIRE & SMOKE CASUALTY ALGORITHMS
- EFFECTS OF SINKING
- DISTINGUISHING 'ONSET OF INJURY' FROM 'INPATIENT'

SHIPDAM
OTHER INITIATIVES

- INCLUDE 'TIME TO REPAIR'
- ADD MEASURE OF STRUCTURAL DAMAGE (PLATING, CABLING, PIPING)
- USE TO PRIORITIZE BATTLE DAMAGE SPARES ALLOCATIONS
- ADD RELIABILITY MEASURES
- ADD HUMAN PERFORMANCE DEGRADATION

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JOINT AGENCY MEETING ON COMBAT SIMULATION ISSUES
CONTINUED SESSION

Thursday, December 1, 1988
Building 381
Room 1306

CDR CONTRERAS: When I talked to Dennis and he asked me to talk to this group, there was a funny pause after I hung up the phone with him. I stopped to think what is it he wants me to talk about? I said, "gee! What he wants me to talk about is the Navy's need for computer modeling, and that is exactly what I came here to find out." My program is a very diverse program. I handle all the 62 exploratory development programs in the biomedical and CBR community. So I deal with quite a diverse community. I take the opportunity to come to meetings like this to learn from the user and the experts basically what they feel the requirements are. That way I can go back with some ideas of what you guys need, and try to incorporate that information into the prioritization scheme that my organization goes through. So what I would like to do this morning (since I can't tell you what I was supposed to tell you), I would like to take the opportunity to discuss with you the Navy R&D structure, because I can pretty well assume that although the majority of you have worked for Navy R&D for many years, you really can't tell me what the structure is all about, or how it works.

It's very important for you to know something about the structure. If you are going to work within it, you need to know how it works, because otherwise you won't be successful in doing what you need to do. The Navy R&D system is quite unique. It's totally different from any other service. The reason I say that is because Navy R&D is composed of three separate and distinct funding sponsors, each with their own philosophy, each with their own way of doing things, each with their own aims and goals. Hopefully they should end up working in the same direction, with the same objective, but there are three separate organizations.

The first organization is the Office of Naval Research. It funds all the 6.1 research. They fund those basic research programs that have a bunch of free thinkers developing novel ideas and innovations. The second funding sponsor is the Office of Naval Technology, my organization. We fund all the 6.2 exploratory development research done in the Navy. Again, we have our own way of doing things. Lastly is the Chief of Naval Operations via OP 98, and the various OP codes. They fund all the 6.3, 6.4 advanced engineering development within the Navy. Program managers for the 6.3 and 6.4 programs are at the SYSCOMs. So it's a very complex situation. The system has both positive aspects and some drawbacks to it. From my perspective I think one of the biggest positive aspects of this type of system is that every time a technology transitions from one funding sponsor to another, it is validated again and reprioritized.

For instance, when a particular technology begins its development within the basic research structure as it matures, eventually it will transition to the 6.2 community, which is my community. When it comes into my community I look at it, and the first thing I do is look at the fleet requirement to determine if it is still valid. Does the fleet still have the problem, and does that problem still need to be addressed and solved? If the answer is yes, then I'll accept it. If it's no, then why proceed with it? The second thing I do is compare it with the other projects within my organization. With my funding constraints, I have to prioritize all my programs. Maybe it was a low priority at the 6.1 level, but I find that it is a hot item, it's doing well, it's a good technology and we need to get it out there quickly, I will prioritize it at a higher level and try to accelerate it out of the 6.2 community into the 6.3 community. When I transition things into the 6.3 community, they in turn do the same thing that I did. They revalidate and reprioritize again. So a program that starts at the 6.1 level which has a fleet turnover maybe 15 to 20 years hence, is validated and reprioritized as it goes up the line. Because in many cases you might have a problem today that by the time that technology gets out to the fleet, it's no longer a problem. Either the scenario changed, or something happened that made that particular problem 20 years back non-significant.

We feel it's a good process for getting the technologies out, because its more mission relevant than the other services. The drawback behind the system is that transitions are hard or impossible if there is no communication between the various sponsors. I sit in what I consider a very prime position because I have 6.1 programs under me and I have the 6.3 community above me. I sit in the middle.

One of my main functions within the biomedical CBR community is to keep looking down at the 6.1 community to see what technologies are they are developing. Because as those technologies develop, I need to have programs out in the future that will be ready to accept the transition of the 6.1 program. If I don't have them in place, then there is no place for the 6.1 technology to transition into. So it takes a nice constant coordination between the 6.1 people and the 6.2 people. Captain Tom Jones was (prior to his present assignment) at ONR Code 12, which is the applications section of ONR. They are responsibie to make sure that the 6.1 technology indeed gets transitioned into the 6.2 community. They are like the link between the two communities. We have worked very, very close with them. Their function is to make sure they know what's going on in 6.2 so they can successfully transition 6.1 products into 6.2.

That's looking down. On the other hand, I am looking up. I am constantly going to the SYSCOMs and looking to see what programs they have. How stable are they? How are they funded? Will those programs be around when I am ready to transition 6.2 technology to 6.3? If they are not there now, I better make sure that I talk to the 6.3 community so that they POM monies. So that when my technology is ready to transition to 6.3 those programs are available, or otherwise I am going to have technology that will die on the vine, because there is nowhere for me to transition it to. So it's a constant struggle. It takes constant communication among the three funding sponsors to get a product from 6.1 all the way to 6.4.

Prior to being at the Office of Naval Technology, I was at the Naval Medical Research and Development Command. I was a program manager for Fleet Health Care Systems, or Combat Casualty Care. There I handled 6.1 through 6.4 in a very narrow field, but I managed the full length. I received money from all three sponsors. That's a very unique situation, not very common within the Navy where you have one organization that is functioning to cover that type of scope, from 6.1 to 6.4; one manager doing it all.

In the other communities you have three separate managers (one for each level of funding) and they must communicate. I had a real advantage of sitting there managing a program from 6.1 through 6.4. There are, as you all know, a variety of types of researchers. There are basic scientists who says "hey, leave me alone, let me think, I need my space. Let me innovate. Let me think. Don't give me any constricted direction. Let me use my technology. I am not going to worry about applying it. I just want to develop the technology." These are free thinkers, and we need them. We need those tech base people. Very important! Those are people that handle future problems. We need them and we need to support them by keeping them well funded.

Then you have the 6.2 scientist. The in-betweener who is probably the type of researcher that says, "I know we have a problem out there, I know what type of technology is going on; let's see what I can do about taking that non-directed technology and developing a product. I know that you need something out there in five or six years, so let me work on it and I'll have something for you."

Finally, you have your advance development people, the scientist who says, "I have got a problem, and I needed to have a solution yesterday." They are very impatient. They want to get things out there quickly. They don't have the mentality of the basic researcher. They are very anxious to develop a product. They get a thrill out of getting that product or technology out to the fleet.

The problem with the system is communications. Communications between managers, and communications between managers and scientists. Communications at the working level appear to be pretty good. Scientists seem to communicate with each other very well with no problem. It's the managers at our levels who have worked for years in a very, very stratified environment that seem to have difficulty communicating.

With this background, I would like to impart to you the four basic criteria that I use in evaluating programs that will in my opinion become successful, will be funded, and will proceed on to an end product. My understanding from the meetings of yesterday and today is that you are trying to bring together the various individuals working on human performance modeling and create a cohesive program in an effort to develop better models for use within the Navy. This sounds like a new initiative, and I assume you are going to need new funding for it.

Well, to survive in today's environment of funding cuts you need to meet four criteria. The four criteria that I use, and I think most of the managers in my area use are:

> Number one, because of the money constraints there has to be a documented need or requirement in the system before we initiate a new program. Furthermore, once you have identified that requirement, you should take the time to understand exactly what the problem is that needs to be addressed. Too many times you take a requirement, (assuming you know what the problem is) go into the laboratory, work on the problem, and then present it to the user and he laughs in your face. That has happened too many times in the past.

It's not the case any more. I honestly think we have made a dramatic change in that area. We need to spend more time with the originator of the requirement, and sit down and talk to him and say "what is the problem? What do you perceive to be the problem?"

Second, develop a well laid out plan with goals and an approach that reflects that you understand what the problem is. Within that plan, have milestones that indicate that you will, as you proceed in addressing this particular problem, sit down at various times with the user so that he can independently assess your progress.

Three, as you develop your ideas regarding a research area, it is important to attend meetings such as this. These meetings provide good access to information you need to understand what the problem is, and to make you aware of what is available already. That's very important in developing an approach. You have got to show that you have made a very strong effort to determine what is available today, what industry is doing, what academia is doing, how are they solving these problems? This meeting has done that very well. You have brought in people that are all doing modeling work, and you are comparing notes. The fact that someone else is working on the same problem you are should not be a deterrent. A lot of people are afraid to include this type of information in their proposals or their game plan, simply because they are afraid that it will affect their chances of being funded. As long as the projects are not a complete duplication of effort, and yours addresses some unique Navy needs, there isn't going to be a problem. In fact, if someone else has a parallel effort going on and you are communicating, it will enhance your project and improve your changes of funding. I see proposals constantly where 80% of the cost of the program is the acquisition of equipment; equipment that could be borrowed from somebody else working in the field. In this regard, parallel research efforts could be very cost effective. It's nice to build up your laboratories with new equipment, but nowadays the money isn't there. So what you need to do is start looking around as you are doing here today and find opportunities to share resources. When we can see that that type of effort is taking place, you have got one up on the program that didn't do that.

Lastly, understand the R&D system. Take the effort to understand how the R&D system works. Know who the program managers are, know who the champions for a particular project are so that you can continuously supply him with the information or the shield that he needs to protect that program once it gets under way. A lot of times we get a request for information from a department or division head, which trickled down from NMRDC, and the first thing that comes to mind is that we have another paper drill. Don't take these requests lightly. When I was a bench level researcher, if I had known what I know now, I would have taken the request for information a lot more seriously. The information you provide is the shield that the program manager needs to defend your program. If you do a bad job in describing to him what you are doing, how can he defend the program? In most cases we think that the more information we give to the program manager, the more ammunition he has to cut my program. It's not the case. The more information you give him, the better able he is to evaluate your program and make a wise decision. In most cases if he understands what you are doing, he is going to defend it; not use that information against you. So take the time to accurately report accomplishments and progress. Write in layman style a very thorough report of the accomplishments, because your program manager is going to take that information, and use it to brief people who know less about the program than he does. He has got to be able to tell those people what you are doing in layman type language. Don't make your accomplishments so complicated, so technical, that only your peers can read it or understand it. They can pick up that information from your publications. What we need is information written like a newspaper article; not a scientific article. The people I will try to explain the program to, defend the program to, that's what they want to hear. That's what they want to understand. If they want more technical information, they will ask for it.

So with that as a background, I have a few figures to help explain the inner workings of each of the funding sponsors. I am going to specifically speak about ONT because that's the organization I understand thoroughly. But take into account that the other organizations have almost identical goals and function basically the same. Each of these sponsors have responsibilities. Most of them are similar to those shown in the first figure.

These are specifically for ONT, but we develop some kind of investment strategy for each of the research areas. We develop an investment strategy, which we call the "mission area strategy" with inputs from OSD, CNO, the Marine Corps, the SYSCOMs, and various other organizations. We address their needs when we develop the mission area strategy.

The responses listed in the figure are the ones I have as a program manager. I conduct and plan programming, budget, etc., for my area. We provide annual reviews of our programs every fall. We invited the world to come and look at our block plans. I'll explain what a block plan is very shortly. Some block plans are classified, so only those people with appropriate clearances can attend, but all services and other branches of government are invited. The second to last item on the figure is very important. We are the organization within the 6.2 community that represent and defend 6.2 programs. If we don't do a good job of representing our programs not only in Congress, but within our own organization, we will lose money. We are constantly competing with other TAMs (Technical Area Managers) for available funds. If a program falls by the wayside, we all compete for the funds. Lastly, we interface with other organizations. Not only other Navy organizations, but within the CBR community we also interact with the Army, the lead agency for CBR.

SYSCOM. As I indicated, we work in partnership with other organizations, and they also have responsibilities. Responsibilities not only to us, but to their funding sponsors. The next figure shows the SYSCOM responsibilities. They serve as principal advisers to our programs. They critique our programs and make sure that our investment strategy is heading in the right direction. The SYSCOMs represent the user and advise us constantly. The SYSCOMs develop and provide documentation regarding priorities, requirements and system needs. We need to know what problems they are having so that we can address them properly. The SYSCOMs participate in ONT planning and reviews. As I said, when we have reviews, and as we develop that block plan, we work with them to make sure that we don't take shortcuts that they are not going to accept. In essence, what they do is provide independent technical assessments of our programs. That is very important. They do the same thing for the other sponsors too. They also work in partnership with the research labs to make sure the labs are the executing our program properly.

ONT RESPONSIBILITIES

- DEVELOP INVESTMENT & MISSION AREA STRATEGIES: OSD, SECNAV, CNO, CMC INPUT
- CONDUCT PLANNING, PROGRAMMING, BUDGETING
- PROVIDE GUIDANCE TO CLAIMANT & PERFORMER
- PROVIDE REVIEW AND APPROVAL OF PROGRAMS
- ALLOCATE FUNDING & FISCAL ACCOUNTABILITY
- PROVIDE OVERSIGHT OF PROGRAM EXECUTION
- REPRESENT & DEFEND 6.2 PROGRAMS
- INTERFACE WITH OTHER NAVY ORGANIZATIONS

SYSCOM RESPONSIBILITIES

- Serve as Principal Advisors to ONT in Development of Investment and Mission Area Strategies
- Develop and Provide Documented, Prioritized Systems Technology Needs
- Participate in ONT Planning & Review
- Provide Independent Technical Assessment
- Work in Partnership with ONT & Labs to Facilitate Technology Transitions

Navy Laboratories. The Navy labs and R&D centers have their own responsibilities. The R&D centers are the people who plan and execute the effective block plan. A block plan is a strategy that is devised in response to the mission area strategy. We split the mission area strategy among the labs, and they decide based upon their resources and expertise which sections they want to be responsible for. The mission area strategy goes out about March. From March until October the labs develop a block plan in concert with the SYSCOMs. I have five block plans out of approximately 200 at ONT. I review those block plans and make sure that it is indeed in accordance to the guidance that we give them.

Prior to block plan acceptance and approval by Phil Sullivan, they are submitted to the SYSCOMs for comment. They'll come back to us with comments and before Phil Sullivan approves that block we have to show to him that we have addressed the SYSCOM comments. Once that block plan is approved, then we have the fall reviews. So it's always checks and balances with the system to make sure that indeed we are doing the right thing. But it's the Navy laboratories and in this case NMRDC, who has the medical laboratories under its jurisdiction, that develops the block plan. They also coordinate with the SYSCOMs and us to promote technology transition. I have a block manager for each of my blocks, and his responsibility and the responsibility of his people is to keep pushing transition.

The block managers are responsible for keeping the SYSCOM commanders constantly aware of what we are doing at the 6.2 level, because these are the people that need to prepare their programs to accept our technologies when they are ready to transition.

Marine Corps organization and responsibilities are somewhat different. The Navy medical community addresses all of the Marine Corps medical problems. We are their medical system. So if they have problems in the medical area we are responsible for addressing them. We need to know what their problems are so that we can incorporate those problems into our mission area strategy. So we constantly work with the Marine Corps. The Marine Corps, like the SYSCOMs, is responsible for developing and providing us their technology needs. To do this they work in partnership with Navy labs to make sure that we are addressing their concerns. Mission area strategy objectives are a list of things that the mission area strategy needs to accomplish. Each one of the TAMs is responsible for developing their mission area section of the strategy. Just

NAVY LABORATORY AND R&D
CENTER RESPONSIBILITIES

- Plan and Execute Effective Block Program
- Work in Cooperation with SYSCOMs and ONT to Promote Technology Transition
- Maintain Communication with SYSCOM Commanders on 6.2 Blocks/Projects

BLOCK PROGRAMMING
OBJECTIVES

- Streamline 6.2 Program Management Structure & Improve Coordination
- Minimize Resources & Time Consumed by Program Reporting, Review & Approval Process
- Improve Program Responsiveness and Minimize HQ Involvement in Execution
- Reduce Program Framentation, Improve Productivity, Relevance, Quality and Allocation of Resources

BLOCK PROGRAMMING
Objectives (Cont)

- Promote Management Efficiency and Flexibility
- Increase Collective Effectiveness by Promoting Cooperation & Coordination Among Navy Laboratories
- Clarify and Simplify Line of Fiscal and Performance Accountability

MISSION AREA STRATEGIES

OJECTIVES

- Provide Program Goals and Guidance
- Define Technology Thrusts Required to Achieve Mission
- Provide Investment Strategies
- Set Priorities
- Define Block Program Ojectives
- Provide Vehicle for Describing 6.2 Program

recently we have gone to a biannual mission area strategy review instead of an annual one. Within the mission area we set priorities and provide investment strategies. It's a five-year program that tells you what we are going to do at ONT in the 6.2 funding area for the next five years.

Recently ONT went to the execution of its programs via block programs. There are a variety of reasons why we went to block programming. As the money becomes more scarce, we have got to be more efficient in doing what we do. So we consolidated areas into block plans to minimize resources and streamline the system. The system also tends to promote management efficiency and flexibility. The system appears to be working. We are much more efficient than we were before. You are forced by budget cuts to become more efficient. If you don't, you don't survive.

I have described the inner workings of ONT. Although what I told you is specific to ONT, the other funding sponsors go through about basically the same routine. Different schedules, different times, but basically, they do the same thing.

My boss, whose office is down the hall, is really not my boss. The person that I work for is the Marine Corps grunt out in the field, and the sailor out on the ship. Those are the people that I work for. Those are the people that I need to know what their needs are. Many times we managers forget that. We get all caught up in power struggles and everything and we forget who we work for. And that's when the system starts hurting.

I have some key issues that I would like to bring up because they are bothering me. When we get requirements from the SYSCOMs often times they themselves don't have a clear idea as to what they want or what the problem is, so it's very hard for the research community to address their problems. I think there should be a better system for having the fleet submit their concerns to the SYSCOMs. Something has to be done.

We have a new program called ATD (Advanced Technology Development). Actually, it's not new in the Navy, but it might be new throughout the other services. The program is designed to help with the transition of projects from 6.2 to 6.3 funding. It's bridge money from 6.2 to 6.3-A. I mention this program because it's a very good system to get a quick transition or an accelerated transition from 6.2 to 6.3-A. If you have a high priority 6.2 program that you think is ready to transition into 6.3 you might try the ATD program. The money is there, but it's highly competitive. Last year I

MARINE CORPS RESPONSIBILITIES

- Advise ONT in Development of 6.2 Program Investment Strategy & Amphibious Warfare Mission Area Strategy
- Develop and Provide to ONT Documented Marine Corps Needs and Priorities
- With Participation from Navy Labs/R&D Centers Develop, Manage & Execute MARCOR Related Programs

EXPLORATORY DEVELOPMENT
KEY ISSUES

- Fleet Input to SYSCOM - SYSCOM to CNT
- Transition of 6.2 Mature Technology Into 6.3 SYSCOM Programs
- Advanced Technology Development (ATD) Programs
- Navy Laboratory/R&D Centers Interaction With the Fleet
- Block Plan Distribution

think there were something like 54 ATDs introduced and only five were accepted and funded. Fortunately, for the first time the medical community had one of the five. In the past I would have said we have no chance in this system, though we do now. It's changing, and people who are making the selections are looking at medical much more closely. The medical ATD that was funded for FY90 start was funded at the $33.8 million level. That's a small ATD, most are much larger. The paperwork to submit an ATD isn't all that hard. Check with your program managers. They will give you information on how to use the ATD to your advantage.

I was very encouraged to hear Captain Cheney's introductory talk regarding what was going on at NHRC. Just about every word he said was interaction with the fleet. He indicated that he had people out in the Persian Gulf, and he had people with the Marines. That is great! For too many years we have conducted research without really talking to the users. We are doing it now, and I think the biomedical community is becoming more responsive to fleet and Marine Corps needs.

I am the only medical person at ONT. All my counterparts are line officers, and I just was getting tired of listening to them bad mouth the biomedical community because we were not responsive to their needs. I don't hear that any more because of the success that we are having in the biomedical community, and it's you people who are doing it. Accomplishments are being achieved and programs are being transitioned. Every week we compete within ONT to submit an accomplishment to ASN. In the last three months we probably have had four from the biomedical community accepted and sent to the ASN. We are very competitive now thanks to you people. The reason for our success is interaction with fleet. We are becoming much more mission relevant in what we are doing. In the past we were not.

I would like to address one last issue before I quit. There is a DOD organization called DMSSC (Defense Medical Systems Support Center). It's the old TRIMIS organization. They have changed the name to hide their past sins. It's the tri-service medical information systems organization. They initially started out as being the DOD coordinators of computerized medical information systems so that as each of the services develop their own medical information systems, they could interact and communicate with each other. They were responsible for all medical information systems that the service developed. When they changed their name, their charter expanded. They are now looking at those medical computer systems that are going out into the operational theaters. That becomes part of their realm also. They have extended beyond the Continental United States.

When we started working on the Navy's medical information systems and computer assisted medical diagnostic systems, we ran head on into that organization. I don't know right now what their specific interest or responsibility is in modeling systems, but if you have modeling systems that you envision being operated within an operational theater, you have got to be aware of that organization. They are not an R&D organization, but they are implementers of the programs. So if you are not aware of this organization, and you come up with a product and are planning on implementing it into the system you might have a problem. To avoid a problem I suggest you communicate with DMSSC early on in your development cycle. Now, I am not sure exactly what their responsibility is with modeling systems, but I would check with somebody in their organization. They are located in Alexandria, Virginia.

QUESTION FROM THE AUDIENCE: What's ONT doing in the computer simulation area?

CDR CONTRERAS: Well, I know that ONT is one of the sponsors of the Naval War College war games. We sponsor those programs. There is another office besides myself, another TAM (Stan Collyer) who is in training. I talked to Stan specifically before I can out here in case I got that specific question. Stan is not doing anything in that modeling area for human performance right now. I am sponsoring the CBR work at the Naval Surface Warfare Center that you saw presented yesterday. I also sponsor the work presented yesterday by NMRDC and NHRC. So, just about everything the Navy is doing in human performance modeling systems you saw yesterday.

DON EXPLORATORY DEVELOPMENT PROGRAMS

I. PROGRAM OBJECTIVES
   A. Maintain Navy technology superiority & provide capability to counter new threats.
   B. Provide technology opportunities to:
      1. Preserve strategic Naval initiative & flexibility
      2. Improve effectiveness of U.S. deterrent posture
      3. Present significant threats to U.S. adversaries
      4. Reduce cost of acquisition & operations & maximize system cost-effectiveness

II. RESPONSIBILITIES
   A. Office of Naval Technology Responsibilities are to:
      1. Develop Investment & Mission Area Strategies in consonance with guidance by OSD, SECNAV, CNO and CMC.
      2. Conduct 6.2 Planning, Programming, and Budgeting
      3. Provide guidance to Claimants and performers
      4. Provide review and approval of program plans
      5. Allocate funding and ensure fiscal accountability
      6. Provide oversight of 6.2 program execution
      7. Represent and defend 6.2 programs to higher authority
      8. Interface with the SYSCOMs: OPNAV; Headquarters, Marine Corps; and Navy Secretariat
   B. Navy Systems Commands (SYSCOMs) Responsibilities are to:
      1. Serve as principal advisors to ONT in development of overall DON Exploratory Development Program Investment Strategy and Mission Area Strategy
      2. Develop and provide to ONT documented, prioritized system technology needs
      3. Participate in block plan planning and review process
      4. Provide independent technical assessments of value of 6.2 program product for future SYSCOM development
      5. Work in partnership with ONT and Navy Laboratories/R&D Centers to facilitate technology transition to systems programs
   C. Navy Laboratories and R&D Centers responsibilities are to:
      1. Plan and execute effective block programs
      2. Work in cooperation with SYSCOMs and ONT to promote technology transition of mature 6.2 projects
      3. Maintain communication with SYSCOM Commanders regarding exploratory development Blocks/Projects
   D. Marine Corps Responsibilities are to:
      1. Advise ONT in development of overall DON Exploratory Development Program Investment Strategy & Amphibious Warfare Mission Area Strategy
      2. Develop and provide to ONT documented Marine Corps needs and priorities applicable to 6.2 program
      3. With participation from Navy Laboratories/R&D Centers, develop, manage and execute MARCOR related 6.2 programs

III. MISSION AREA STRATEGIES

Mission Area Strategies establish the DON 6.2 program objectives for each mission area in terms of the operational impact of the planned technology program on the warfighting capabilities of the Navy and Marine Corps.

A. MISSION AREA STRATEGIES SHALL:
   1. Provide program goals and guidance
   2. Define technology thrusts required to achieve mission
   3. Provide investment strategies
   4. Set priorities
   5. Define block program objectives
   6. Provide vehicle for describing the program

B. MISSION AREA NEEDS
   1. Maritime Strategy Technology Area Concerns
   2. Threat Drivers
   3. System Deficiencies
   4. Programmatic Drivers: high-level guidance which drive priorities and schedules

IV. BLOCK PROGRAMMING

A. Ojectives of Block Programming
   1. Streamline 6.2 program management structure & simplify & improve coordination between headquarter & performer
   2. Minimize resources and time consumed by program reporting, review, and approval processes
   3. Improve program responsiveness by instituting management-by-objectives policy and minimizing head-quarter involvement in execution management
   4. Reduce program fragmentation, improving productivity, relevance, quality, and allocation of resources
   5. Promote management efficiency and flexibility
   6. Increase collective effectiveness by promoting cooperation and coordination among Navy labs
   7. Clarify and simplify line of fiscal and performance accountability

B. Block Plan Distributed to SYSCOMs for review prior to final approval by ONT

C. SYSCOM Comments are addressed prior to submittal for approval

D. After final approval is given, Block Plan is review again at Fall Review

V. TRANSITIONS

A. Coordination and cooperation amoung SYSCOMs, Navy Laboratories/R&D Centers and ONT

B. Advance Technology Development Program (ATD)

VI. FLEET INPUT TO SYSCOMS

A. Improve process for submitting operational requirements and needs to SYSCOMs for incorporation into Mission and Strategies and address by Block Plans

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WORKING GROUP TASKING WITH LCDR DENNIS KELLEHER

LCDR KELLEHER: I can read lips as well as anybody else, and reading lips says that we have to deal with the modeling of human performance as a new initiative which places some constraints on development, but we can handle that. I don't think we have a problem identifying who our sponsors are going to be. The Marine Corps has just established a new war gaming center. That new war gaming center is just getting off the ground and so maybe we need to go talk to them.

I was kind of interested yesterday to hear about the limit to which the Naval War Gaming Center at Newport cares about having realism imported into their games. Maybe we could help educate them a little bit better as to the degree to which some more realism within their models could be effectively used.

So we need to sit down with CDR Contreras and Captain Jones and identify specific lists, if you will, of who our sponsors are going to be, who our identified requirements and customers are going to be within the SYSCOMs.

This meeting was actually funded by NHRC (with Med R&D Command's blessing) as a new research initiative. We felt so strongly about beginning this initiative that we funded it ourselves. Individual principal investigators felt that this was going to be a promising technology that could help focus our individual research efforts so we convinced Captain Chaney to support this initial effort. From here on out, however, the technology must stand on its own merits.

The word we have from Captain Jones is that this technology will be something that will be encouraged of all principal investigators within Medical R&D Command. Computer modeling should not be the sole impetus for their research efforts, but it can serve as a focus for requirements, prioritizing efforts, and packaging product to the user. So what we want to do is be able to provide to CDR Contreras and Captain Jones, (who are our funding sponsors) the guidelines for making certain that these things are incorporated into future research efforts.

CDR CONTRERAS: Remember that this type of program isn't limited to medical. The weapons centers have just as big a responsibility and they need the information just as badly as we do, so don't forget them as a possible funding sponsor for some of these programs.

LCDR KELLEHER (NHRC): I think from the discussion of the AURA model we saw that there was a methodology, for accepting basically any kind of input data. In fact, as was pointed out by Dr. Kolpcic, the AURA methodology relies upon getting the actual data from the end user and from the laboratory researcher as it's produced by them. That leads also to the question of how do we exploit the data bases that do exist to find out whether there are areas that need further development? Have we fully exploited the data bases as they exist now? Have we incorporated the available data into models? Models such as AURA that accept a broad spectrum of inputs need to list or indicate the types of data they are looking to incorporate. Are there areas that are specifically lacking that we need to be working on?

DR. GUNDERSON (NHRC): I was glad to hear CDR Contreras say there may be a possibility of working with other groups (non-medical groups), to perhaps realize some of the goals that we have been discussing here. But I would like to say that at NHRC the impetus for us is to have a means to represent combinations of physiological and psychological variables that produce degradation of performance. So essentially we would tend to concentrate on medical aspects; that is, we have the expertise to look at possible measurement of physiological degradation, psychological degradation, and that's what we would focus on, and that's what we need the model for. In this case, we are the end user, and need the model as a tool of our trade. We may be able to use some other models and plug in our variables. Our principal concern is how do we utilize this methodology in the research process.

Secondly, I think to be responsible advisers to the various commanders who want answers to questions we have to have means to rapidly assess the problem and determine if we have the answers to their questions, and here I think modeling may play a role in the sense of helping us project results which we don't have yet. We can see and we have seen, that these systems can be designed to integrate the weapons systems, the personnel data, and the medical data. We believe this may be quite a useful tool, and that's the way we look at it.

MR. PUGH (NHRC): Just to expand upon that, I think what we have done at Naval Health Research Center historically has been in the context of epidemiological analyses. Answering questions and coming up with tests of a hypothesis. I think what modeling does is come up with answers to user's questions in an interactive fashion. As I see it, we are continuing our role of coming up with answers to medical questions, but not necessarily in the traditional manner. Modeling provides a method for real time handling of spontaneous user questions in an interactive fashion. I think that's one step beyond where we have been traditionally.

DR. KOLPCIC (ABRL): I think it's going to be pretty important that you differentiate between the models that would be developed in a particular community like the medical community, and the large scale model, the combat simulation that is going to take all of these models and interface them together. We want to make sure when somebody is talking about a model we know what level of model it is. I believe Dr. Pugh's comments would pertain to a model that he would develop in his shop to answer questions on his particular area. That's not necessarily the model that would be usable by the Janus person who is worried about putting the whole thing into a large simulation.

LCDR KELLEHER (NHRC): There is no question that the model that Bill Pugh is developing on DNBI (Disease and Non-Battle Injury) is going to be a very valuable input that combat simulation modelers should be aware of, because in fact, it is a much more sophisticated view of the generation of DNBI casualties, which is an output which is needed by the combat simulation modelers. So not only are we defining inputs to a model which may be generated to look at a specific problem, we also have to consider that output needs to be viewed as an input to somebody else.

DR. LAUGHERY (Microanalysis and Design): I think we are talking about two kinds of models here. First is the relationship between the stressors and some types of human performance, and that's the stuff that people have been doing for years in the lab; what I call performance shaping factors, performance degradation functions.

What we need then from my perspective is a matrix of models relating psychological and physiological variables with different types of performance tests. So one of the first things we have to do is define that matrix. You know, what are the stressors we are interested in and how do we want to characterize the tasks? This will give us all a common framework to do our research in. The models for the matrix can be built in the labs around the country. The models don't even require the collection of field data to build them. The scientific literature is full of data that could be used to build these models.

The other kinds of models are situation specific models, a model of an Army platoon in combat in some particular combat environment. Those are the things that the users are going to have to do because they are the ones who want to study that. From my standpoint you separate those two kinds of models out very clearly, then the researchers can understand what they have to do and the users can understand what their job is.

DR. KOLPCIC (ABRL): Understand what Dr. Laughery said, which is pretty much in agreement with the statements that come out of the medical people here. That is, the medical people and their labs have their job to produce their data, to make their measurements, to make their model of what happens as a function of stressors, and that's where their job ends.

It is the responsibility of the combat simulation person (the person making the big aggregate model) to come and get this medical model, to learn enough about it so that he can take the outputs from the algorithm and make it produce a Delta at the end of his simulation. That's the statement that's been made. I think we just ought to discuss that. Do you think that's really where the responsibility lies?

LCDR KELLEHER (NHRC): I'll be very frank. I disagree. And I'll disagree with a very specific example. Lee Marsh, who is sitting in the back of the room, is a former Marine who used to run a TWSEAS site and is now a contractor for the redevelopment of TWSEAS software so that it is a more open input system that will accept, just as Janus will accept, a variety of inputs. He didn't know where to go to get the medical input to be able to modify his performance modules. We need to have someone or some organization that brings these two groups (the laboratories and the combat simulators) together.

DR. KOLPCIC (ABRL): The best way to make sure it won't get done is to escape responsibility.

DR. HARRISON (UC Davis): The first thing I noticed in the presentations was th** not a great deal was said about the degradation of the opposing force. Now it may be assumed that that's going on, but obviously the relative fitness of the two forces is important, not just the fitness of our own force. If you are down to 70% efficiency, it's one thing if your opponent is 100%, and something else if they're down to 30%.

The other thing is, I would really like to reinforce your suggestion of separating out the cognitive or psychological elements, both as inputs and outputs. A person who is very stressed may make a very different decision, and have a significantly greater impact than someone with an altered motor response. So I would like to put in a plug for the cognitive element in these various models.

MR. PUGH (NHRC): What this all makes me think about is computer networking and the interface problems different systems have. With some forethought different systems can be plugged into the network in a modular fashion. So I am wondering if this isn't in fact just a specific case of that same problem. We need to come up with an agreement of what the plugs should look like for the overall system and have the mutual understanding that the developers of modules will produce programs that interface.

DR. KOLPCIC (ABRL): That's a nice idea in principal. Unfortunately, we have such a variety of models, and the models are much more different than the nodes on a computer net. A model that uses a brigade as its smallest element or at least a battalion as its smallest element, requires different kinds of input than one like AURA or Janus or SEES, in which the smallest element is an individual. With the individual I can take the output pretty directly from one of Dr. Naitoh's sleep models, and I know what to do with it. But if I am trying to do this aggregated over a battalion, somebody has to make the decision on how to aggregate the input differently, how to aggregate it appropriately.

DR. CRISMAN (NAMRL): One thing that has been developed for '88 is a modeling committee with representatives from each one of the Navy medical labs. One of the tasks of this committee will be to compile a list of data bases that each lab has that are utilizable for modeling. We will also be looking at each lab's resources and determining what their capabilities are. This information will then be put together so that the committee will have the information in one spot, and they can then act as a conduit between the tri-services and private industry. The committee is just being formed at this point, but I see it answering some of the questions that have come up about how are we going to coordinate the modeling efforts.

DR. LAUGHERY (Microanalysis and Design): At least in the near term, let's not try to build human performance into brigade models and things like that because we'll bite off more than we can chew. I think the place to be right now is at the small unit level. If not one individual certainly a small group of individuals, you know, like a tank crew or a fire team. I think if we try immediately to incorporate human performance in big models, we are in trouble.

LCDR KELLEHER (NHRC): Well, you have to know that most of us here feel the same way. We are crew based in our concern and I think we all realize that our efforts at the laboratory are never going to extend beyond the analysis of the performance of the individual and the small unit.

DR. NAITOH (NHRC): I would really like to reinforce what has been discussed here about the small models for performance. I must tell you, however, that building a performance model is not a trivial task. We did the metanalysis of the research literature on sleep, and found about 500 variables that are involved. Now, that's almost impossible to deal with.

MR. HAWKINS (DTRDC): I have a different point of view. I think rather than looking strictly building from the bottom up, from the smallest unit up, you ought to start simultaneously looking from the top down. If you wait to build it from the ground up, it's going to be ten years before you can put it on a ship and show the value to the people who need to see it. Secondly, I thought coming here I would at least walk away with a list of what causes human performance degradation. I thought I would have definitions when I left. I thought I would know somebody to call about each of those. And I am not getting that.

LCDR KELLEHER (NHRC): I did show the slide yesterday quickly, and it certainly is nowhere near being all inclusive, but it's been the areas that have been looked at in the past. I also showed the types of physiological and psychological degrading factors that occur.

MR. HAWKINS (DTRDC): Along with that, are there measures of effectiveness for human degradation? If we don't agree with that, where will that ever happen? Will we all go off and use different things?

CAPTAIN J. HOFFMAN (NPGS Monterey, TRADOC): I came down here from Monterey where I am working on a project designed to find strategies to improve high resolution combat models such as Janus. At the Naval Postgraduate School and within our research group itself we have the same problem that David Taylor Research Center is having. We can't decide what the important variables are. We would like some answers from the research community. When you build a computer driven model you are limited for practical reasons of hardware and memory in what you can do and still have a workable model. What variables do we need to include that make the most difference? If you talk to the operational community you don't get any real answer, and if you read the literature you get a million variables. That is one of the reasons why the users and designers of high resolution models have not been really interested in incorporating human factors as a broad class into those models, because we don't know where to start. I would be more than happy to talk to anybody who had any theory, idea or suggestion on where to start.

Perhaps sleep deprivation is a place where you could say that's a broad class and we'll start there. I would even limit it further. I would say what does sleep deprivation do to target acquisition? If somebody could build a functional relationship or perhaps some interpolated data or table that would be usable, but guess what, nobody has done that yet, and that's where we are at.

DR. LAUGHERY (Microanalysis & Design): Captain Hoffman's got it. That's what I said before in a less direct way. The stressor variables listed along the top of the matrix I described have to be the variable that matter. What are those variable stressors on human performance? That's where we need to focus our attention.

LCDR KELLEHER (NHRC): Let me pose the counterpoint that if you did that limited analysis of stressors on limited functions, then I would have to ask you as a researcher what does that mean to the combat task performance, which is what is actually being modeled.

DR. KOLPCIC (ABRL): Deltas. That's what you want to know. Delta.

MAJOR ANDERSON (TWSEAS): Within TWSEAS, the biggest deficiency is the lack of human performance. You know, electrons (like I said yesterday) run 24 hours a day and they never get tired.

To correct that, I think we should start both at the bottom and at the top. If you don't start at the top, we will all be retired and probably dead by the time it finally shows up. As a user, I am willing to accept just about anything that puts more realism in our model. It doesn't have to be exact, it does not have to be perfect. I don't need something so damn complicated that I can't use it. That doesn't do me any good. That doesn't do the people I am working with any good. Lee Marsh is putting something of that in the revision of TWSEAS, but we still have a hell of a long way to go. Right now anything is better than what I have.

CDR CONTRERAS (ONT): I agree with you 100%. One of the biggest headaches we have in the laboratories is trying to take a model and tweak it and tweak it and tweak it to get 100% resolution of the problem when 80% will do. You need to get that thing out in the fleet as soon as possible. The time and cost of tweaking that model from 90% to 95% is enormous, and to go from 95% to 99% is even much greater. If you are going to keep the technology in the laboratory until you get that 99% figure, by the time you get it out to the fleet it will be obsolete. So get something out there as soon as you can for the user to use and then continue working on it and build on it, but after it's out there. Because 80% of something is much better than 0% of nothing.

MR. PUGH (NHRC): I would like to throw this ball back to the other side in the sense that before we can say what causes it, I think we on the "our" side have to get a better idea of what it is. One suggestion was that target acquisition as a human performance was important. I think if we had a list of criteria such as target acquisition or firing rate, etc., we could develop relationships between the criteria and a list of human factors. Until we do that we don't know whether the human factors relate to criteria.

LCDR KELLEHER (NHRC): Well, again, harkening back to the Intermediate Dose Program, that was essentially done in the early stages of that program. In the Intermediate Dose Program the Defense Nuclear Agency knew that it could not define for the Army what were the essential things that the Army thought were important and needed to be done on the battlefield. So the Defense Nuclear Agency went to the Army and said, "all right, we can't do everything, what are the essential, most highest pay-off combat tasks that we should analyze for you to get a better estimate of performance degradation on the battlefield? Probably the same thing needs to be done with the Navy and/or the Marine Corps. We actually have a contract right now which is being let in San Francisco and will identify those tasks for us infantry riflemen.

To my knowledge, we don't have an identified set of combat tasks shipboard. That should be our emphasis. Maybe we need to do that. What are the crew tasks that are performed shipboard that will have the highest pay-off given a scenario dependent engagement?

DR. PAUL KIRK (NSDC): Dr. Rodonwyn Carson at NTSC over in Orlando, Florida, is doing essential task analysis on shipboard tasks and she might be a good contact.

DR. SHELDON LEVIN (Technical Southwest): I was very impressed with the book that was put together by Burton Banks, et al. They did an interesting thing which I hadn't seen done with models before, and that is they tried to put them in a very systematic way. It kind of asks the same questions about each of these models, and I was impressed with that effort. I had not seen anything like this done before. Now, the same thing needs to be done for the biological models.

There are people that will model performance degradation (let's say from radiation) by saying, at no radiation the performance is 100% and we know that a 450 rad exposure will kill you free and clear, so we'll say it's 0% performance at that point, and let us draw a straight line in between to describe a degradation function. I made up this example because I want to make a point. Nobody would actually do anything that crude, although I have seen things done almost that crude, and they were called models. At the other end of scale we have complex models like AURA. Data for this model was gathered from a wide variety of sources. One source was the IDP program, which had the efforts of about 20 people for about six years devoted to producing some very nice results, and that's only one input that went into the AURA model.

My plea here is for some kind of equivalent look and summarization of the kinds of performance models that people have built. It would really be important to have an honest evaluation that describes what went into each model. Was it really based on actual measures taken on 10,000 people sleeping, or was this based on an epidemiology study, or was it based on a conjecture of an engineer. I think the publications put together for this meeting would really be tremendously helpful to me, and I suspect to others, and for this meeting; it's an excellent start. I plead for the same kind of thing for the human performance models.

DR. NORM LANE (Essex Corporation): I have been encouraged by the free flow of information taking place here, but I am getting a little bit discouraged, because it makes me tired to think about taking all of the tasks that any military person might do and lining them up along one axis of a matrix, because there is going to be 20 or 30 or 40,000 of them. Then to try and make estimates of degradation as a function of a half dozen matrix stressors seems like almost an impossible task. Most of the things that military people do are probably made up of perhaps two or three major performance factors. Those are probably reasonably well understood. I think what we need is something like a dosage equivalency model for each of those stressors that maps them into something that looks quite a bit like what came out for ionizing radiation. Once you have got that, you can put everything into the same framework. You can show it to people, and it's a piece of cake to implement the model.

Performance variables probably need to be organized around something very simple like cognitive and motor performance. Most of the human performance models I have seen working in the bigger models use something really dumb like cognitive, motor, visual, etc., and those tend to work. When they get more complex than that, they start collapsing under their own weight. So I would at least advocate trying to get a common matrix like time and a common dosage equivalency model. Anybody should be able to do that as medical people. That's where it came from, and then we can talk about whatever stressor you wish to talk about and make them equal. It also makes the combined stressor discussion a hell of a lot easier.

LCDR KELLEHER (NHRC): George Anno, would you agree that without the additional validation steps that are anchored on combat task, performance would be acceptable?

MR. ANNO (Pacific-Sierra): I think it's a great idea, but let me tell you what happened to us when we tried to identify the specific performance tasks that are needed. After a military meeting at TRADOC that dealt with military tasks we got the behaviorists together to get their blessing on a set of basic performance tasks. Well, that was the biggest cat and dog fight we had ever had in our life. People actually got up on the table just about, and were pounding and everything, so if you are going to do that, you are going to have to sort of select your behaviorists in some way. Because if you don't, no one is going to be able to agree on a taxonomy of performance tasks.

I think we finally ended up doing our own taxonomy, which is sort of a taxonomical subset, and is more or less geared to the stuff we needed to do. We had to really get down to fundamental definable things that those Army guys can understand. If you are ever going to go out to the fleet, service those people, and cooperate in your study, you are going to have to deal in tasks and terminology they understand. We gave up on this marvelous behavioral taxonomy thing and did our own taxonomy and that seemed to work. But I agree in principal with this approach, no question about it. It is a beautiful academic approach, but you are going to have to fight a lot of battles in between and compromise, no question.

DR. LAUGHERY (Microanalysis & Design): The way I think of it, because I have been there before, is just pick a taxonomy, any taxonomy and just stick with it. There are lots of famous behaviorists and each has his own taxonomy. Just pick a taxonomy and stick with it, because that gives everybody a common framework. The joint working group that sponsored MicroSAINT spent a lot of time preparing a taxonomy. Dr. Ed Fleishman was one of the individuals that worked on the project.

MAJOR ANDERSON (TWSEAS): I think some type of standardization is desirable. Certainly it decreases the amount of misunderstanding.

DR. EARL ALLUISI: One of the ways of approaching the topic we are discussing right now is to start at the other end. Start with combat simulation models and find out what is important to the outcome. I would like to get behaviorists on the side of the combat simulation modelers, and let's identify some of the systems that we think are affected by human performance. Psychologists say sortie rate will be influenced by human performance. Certainly that's going to be affected by human performance both in terms of the quality of the maintenance people who are turning around the aircraft and their momentary condition in terms of fatigue or other stresses. Now perform a very simple sort of sensitivity analysis using the combat simulation model. Let's go in and see what the outcome of the battle is; day one, day two, day three, day four, day five, with the human performance program set at two and one half. If you double it, if you half it, does it have any effect? What effect does it have? Then do that for several other primers that we think will affect the outcome. One study has done this, Sid Dutchman did it at IDA, but the publication is not out. He used the TACWAR model and varied several of the parameters to determine what affect it would have on the major criterion, movement of the tank in the field. If we did this for our sortie example you would probably find that sortie rate doesn't have any effect. If you understand how the Air Force is going to fight the war where their first days of combat are devoted to neutralizing their threat, then you can understand that sortie rate would not have an effect on a ground war. There are other things that have a major effect on a ground war, but sortie rate doesn't. Rate of fire. Is that affected by human performance? Or is it completely determined by the equipment? I think it's affected by human performance, and I think rate of fire will probably turn out to have a greater effect on the ground war if you alter the human performance module in your combat simulation model.

Let's stay on this approach for a while longer. Now we have identified some important systems that will really affect the outcome of a combat engagement in at least as simulated by our model. We assume the model is good, correct, validated or can be validated. Now comes the guidance for the laboratory because once you identify critical systems, the modeler will have to get with other scientists and get the appropriate algorithm or function. At this point it's not merely using a factor of two. I would like to know at this point what the effect is going to be as a functional relation in terms of outcome of military value. That's the way (from my point of view) that we can get started on this project and not waste a lot of time on stuff that doesn't really matter. We can identify the most important things that are going to affect military outcomes. That's the name of the game; what is the outcome!

As for the Naval Health Research Center, you can pay your way for the next ten years easily on one good identification, and you can do that because I know that human performance is going to affect the outcome on some of those systems. The next step is what does it cost to do that? Say we are dealing with protective clothing. To give them protective clothing or to give them additional training, or to have more stringent selection or to put twice the number of people in the system; so you have redundancy of people like redundancy of equipment, what does it cost? What are the benefits in terms of military value? What does it do to the outcome? Now, let's also compare that with alternative ways of getting the same outcome through some other variable. Take "rate of fire," for instance. I can change it by getting a new weapon or getting a new weapons system, and I could now begin to do what we have all said we should be doing, get real trade-off analyses. What does it cost; what is the effectiveness of doing it by twice the number of people with these guns, or 600 ships instead of 300 ships. With this type of model and analysis maybe we can start to get some reasonable decisions.

The credibility of these future decision will be based on military value. Combat simulation modelers are going to be some of the most important people in my world, because I think that's the only handle I have on this type of trade-off analysis. I would like to give you a general overview of our organization. The Department of Defense is made up of the Office of the Secretary of Defense, the defense agencies, the Organization of the Joint Chiefs of Staff, the unified commands, and the military departments. That's the Department of Defense. Within that organization OSD (Office of the Secretary of Defense) has three jobs, two written and one implied. The first job is to establish the policy under which the military department is operating. The R&D side establishes R&D policy. Secondly, we provide oversight. That means we watch how they are executing their program, and insure that it is consistent with OSD policy. The third part which is not usually written up, but which I think is the most important, is advocacy. I tell the people in the S&T (Science and Technology) reviews that their first job is to get their program into the budget. That means you have to get together in the R&D community along with the operational user community, and develop a unified advocacy within your community. Because unless you are in the budget, my hands are tied. I can't do anything. Once you are in the budget, then I can do lots of things.

Most of the things that I can do easily are negative. The things that will boost your program along take a little more effort, and that rarely gets done. We can tell the Navy that they don't have enough support in a given area, and they should do more, but it's got to be done a certain way because if OSD tells the services to do anything, they tend to tighten up and stonewall the effort.

There are some changes going on this year that you ought to be aware of. We all expect defense spending to go down, and what happens when total funding goes down is R&D goes down by a greater percentage, and when R&D goes down environmental life sciences go down by even a greater percentage. So coming full circle, one of my jobs is to protect R&D programs. To advocate and protect the programs of all the military departments in my domain. In our little directorate there are five of us and we cover mechanical warfare, environmental protection, environmental considerations--which is primarily meteorologist, biomedical, and training and personnel. The biomed area is covered by Captain Ray Sphar from the Navy. We work closely together and split certain of the program elements.

We now work under the Novar Nichols Act. We used to have an Undersecretary for R&D, and our program was in the engineering section. A new Undersecretary, the Undersecretary for Acquisition, was created, and the Director of Defense, Research and Engineering will be recreated and will report to the Undersecretary for Acquisition.

Until this year the policy was to have the services brief RSD as to what its investment strategy was. This year they turned it around and RSD is going to brief the services on its visions and goals. The direc_, has asked each of us to put together a program that will go in DOD's Science and Technology Advocacy book, which will be taken to the four committees in Congress that are important for us. In putting together DOD's visions and goals, we had to be specific and we had to give estimates of the payoff. We had to provide very clear directions as to the effects the effort would have on military capability.

Number one in combat mission tactical training is a program that emphasizes networking of simulators for training, but also for situational awareness, for mission rehearsal and possibly as a battle management aid. I think this initiative is going to be one that the director is going to push, it's the one that's closest to what we are talking about here today. Remember however, I said training because that's in my title and they understand that. But training is always in my usage a very broad term. It includes all of the human performance aspects, including the degradations, the avoidance of the degradation or enhancement that we can get through all the techniques that we have.

I think we can come out of the program reviews in good stead if we keep ourselves product oriented. We have got to be specific in terms of the deliverables that we are going to produce. That means measure and evaluate in terms of military value. That's the way we can survive and probably the only way we can survive. An important piece of this initiative is a transition plan. If you do the first part of the development and don't keep tying it in with the user and insist that the user keep tying in with you in a meaningful way, the program will at best be delayed and at worst die. I insist that before we put any big money into a development that we have written agreement from the user at an appropriate level. For example, if it's a training technology to go to a school, then I get at least a Two Star Admiral from TRADOC, and a Two Star General from the Training Command to agree that if the technology is successful during the demonstration field test and evaluation, we will implement it. Then they say, "what happens when it comes in this year and funding requirements are higher, I said that's your decision." You do what's best for your service.

That's what I mean when I say get together with the user. Not a junior officer teaching a course in the school, not a junior physician who is walking the ward of a hospital. You have got to get to a user who has the authority to make it happen, and get his commitment that he will implement.

LCDR KELLEHER (NHRC): I am not sure how we come together and summarize the outcome of this meeting.

DR. LAUGHERY (Microanalysis & Design): One way we could probably summarize the meeting is if we summarized some of the basic questions that people had that are leaving here unanswered, and then also those that they had that have been answered.

LCDR KELLEHER (NHRC): Thank you. That's an excellent suggestion. Which questions were not answered based upon the expectations that you came to the meeting with? Jack Hawkins, you have already suggested that there are several that you had and that you thought you would get an answer for.

MR. HAWKINS (DTRDC): I don't know what the measures of degradation are, and the meeting hasn't clarified that for me. I would like to see an all-inclusive list of factors that degrade human performance. I would also like to see the list weighted by which ones are most important.

MR. ANNO (Pacific-Sierra): I thought we didn't really touch enough on validation, which gets into the measurements you are really interested in. It just seems like validation is the bottom line. Validation is the thing most operational people are interested in. You have got to convince people that the model really works.

LCDR KELLEHER (NHRC): Should there be an identification of criterion of validation, or a criterion for inclusion of degradation factors, or a criterion for inclusion of a performance decrement factor? Should these be things that have identified criteria that everybody agrees on?

DR. TERHUNE (LLNL): I really feel like I need to learn a lot more about the human degradation factors, and the human factors that cause people to behave in different ways than expected, depending upon the stresses that are put on them. I don't have a good understanding of that process, so I am going to have to learn a lot about that before I can begin to think about how that's going to be modeled. I think also that a lot of the researchers that have a better understanding of that need to learn a little bit about modeling in order to understand how the direction of their measurements, and their tests and their experiments are to go.

I think Dr. Alluisi brought up an important point. There is no sense in making detailed measurements on stuff that's not important in the primary analysis. I think we need to attack those things that are most important first, learn from them as we go, build very crude simple models to start with, and then define them as we go.

So I would suggest that we have another meeting in six months and that in the meantime people prepare some papers on some of these areas so that we can begin to learn from each other.

MR. ANNO (Pacific-Sierra): I think between now and six months from now you could summarize what we have done here and use the Delphi technique amongst the attendees to get a consensus ready for the next meeting. That would put us a lot further along in understanding each other and having unified definitions.

CAPTAIN HOFFMAN (NPGS, Monterey, TRADOC): I would like to know more about the specifics of the models, (the existing weapons models) and what programs are involved so I can get an idea which programs may be affected by human performance. I don't think this meeting has given me enough knowledge in these areas.

MR. ANNO (Pacific-Sierra): I think if modelers sat down and listed some of the human performance issues they are facing as modelers, it would help define the problem. If the modeler then had an organization or group of individuals to turn to that could look at his list and say, well, you know, this is not realistic, this relationship just doesn't exist, or it does exist, or we have/haven't quantified it, things of that nature. With that type of feedback and exchange back and forth we could start to learn, both communities will begin to learn.

MR. STROM: As a model developer I would like to know what are the things of concern to the users of the models. We have found that it's sometimes difficult to get enough information on what it is the user wants. To give one specific example, in the SEES project, we are talking about item level resolution, human versus human, how important is marksmanship to analyzing an assault, and if marksmanship is important to the outcome, then how does fatigue impact upon marksmanship? Finding data to answer this type of question is at best (and often) impossible. So I agree with several comments that have been made so far, and that is there needs to be more direction from the user to the developer.

MR. HAWKINS (DTRDC): What if we were really successful in making this an important aspect of design of military weapons systems. I think we would have to end up at some point being part of the development process, and this might be a way to focus the effort.

DR. HARRISON (UC Davis): You might really want to encourage people to write in with suggestions, particularly if there is going to be a follow-up meeting. I love this idea of the Delphi technique.

LCDR KELLEHER (NHRC): One suggestion that was made by Lawrence Livermore is, they serve as a clearing house for information exchange. They have the capability of setting up a global electronic network of modelers and performance investigators. Would that be something that would be helpful to set up in addition to other mechanisms?

CAPTAIN JONES (NMRDC): I think that from my perspective what I need to do is get a much clearer notion as to the vehicles that we have currently in place, in order to come to grips with an effective vehicle that will do what we want done with it. We have a DOD working group in modeling. Why can't we use that vehicle rather than developing another sort of vehicle?

We have a lot of these committees, working groups, whatever you want to call them, that have as their primary charter the exchange of information with in-services and cross-services. At some point in the future we should come to grips with what would be the appropriate vehicles for the management of the modeling research programs under the cognizance of NMRDC. We will develop this strategy over the next few months.

LCDR KELLEHER (NHRC): I would personally like to thank you all for coming to this meeting and contributing your ideas to what promises to be an exciting new technological area.

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Summary of Joint Agency Meeting on Combat Simulation Issues
as presented at the
Military Operations Research Society (MORS) Conference
21-24 February 1989

By
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Military Operations Research Society (MORS) Conference
February 21-24, 1989

JAMCSI (Joint Agency Meeting On Combat Simulation Issues) Conference Summary

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The joint Navy/Lawrence Livermore meeting (JAMCSI) was held at Lawrence Livermore National Laboratory on November 30 and December 1, 1988. The meeting was intended to bring together individuals from two different research communities: the combat simulation and war gaming community, and the human performance community.

It was intended that the meeting provide a form for the exchange of ideas and concepts with the ultimate objective of improving the fidelity of combat simulation modelling.

As background for the meeting two publications were given out to each attendee:

> "Review and analysis of the literature in the area of human performance modelling," UCID 21558, Lawrence Livermore National Laboratory, November, 1988.
>
> "An inventory of wargaming models for special warfare: candidate applications for the infusion of human performance data," UCID 21551, Lawrence Livermore National Laboratory, November, 1988.

The first day of the meeting was devoted to presentations on existing combat simulation models and their attempts to incorporate human performance information. Speakers provided an overview of some of the more widely used models and outlined the rational for the model's development, its current use, and the strategy being used to incorporate human performance information.

The list of topics and speakers were as follows:

Human Performance Research at the Naval Health Research	Captain Chaney NHRC Center
Overview on Navy Modelling Needs	Captain Jones NMRDC
Meeting objectives and organization	LCDR Kelleher NHRC
JANUS Model	Dr. Tonis LLNL
Crew III	Mr. Anno Pacific-Sierra-Eaton
SEES Model	Dr. Terhune LLNL
TWSEAS Model	Maj. Anderson USMCB Pendelton
AURA Model	Dr. Kolpcic ABRL
NURA Model	Dr. Yencha & Dr. Kirk NSWC
Micro SAINT	Dr. Laughery Micro Analysis & Design
SHIPDAM	Mr. Hawkins DTRC
Human Factors Modelling Requirements	CDR Contreras ONT

The evening dinner speaker was Col. John Pickering (USAF Ret.) and he provided a historical perspective to the development of the military's interest in combat simulation modelling.

The second day of the meeting was to be devoted to future combat simulation models and work groups were requested to deal with design and specification issues. The original agenda had to be abandoned when it became apparent that there were several issues that needed to be addressed by the entire group. Before the meeting was opened to general discussion Commander Tom Contreras from the Office of Navy

Technology gave a presentation on the organization and structure of the research administrative environment and the hurdles that faced any new research initiative.

The open discussion was completed with a short presentation by Dr. Earl Alluisi from the Office of the Under Secretary of Defense. Dr. Alluisi indicated his strong support for computer modelling and the use of combat simulation for evaluating various defense alternatives. He said that he was supporting a major research thrust in this area because of the wide spread potential for this technology.

To bring you up-to-date on the Navy/LLNL meeting, I would like to summarize some of the major points made by the presenters at the meeting.

Captain Chaney outlined the numerous human performance programs currently underway at NHRC and indicated that these research programs, along with the individual researchers involved, were available to support the combat simulation effort. He felt that the human performance research that is going on in the Navy medical laboratories was an untapped resource and, that if appropriately applied, could enhance the fidelity of combat simulation models.

Captain Jones directed most of his comments to human performance databases. He indicated that several Navy laboratories were using the MICRO SAINT software product to organize and develop human performance information. He felt that the human performance modelling development in the past had been hampered by both hardware constraints and the lack of user friendly software, but that both of those barriers had now been over come and that it was now time to develop the supporting data modelers will have to deal with:

1. The goal of the model.

   Modelers need to identify the users and bring them into the development process early.

2. How good is the model?

   The model has to make things easier for the user and the user has to be able to believe in the results. To do this we must make sure he knows what assumptions went into the model and he must know that the results are valid.

3. What databases are available?

   We need a major effort to bring together the various fragmented databases and make them generalizable for use in the various models.

4. How do you get fleet support?

   Captain Jones suggested that there are four elements in getting fleet support. They are:

a. Existence of a valid requirement.
b. An identified user.
c. integration within existing technology base.
d. A transition plan for moving the technology along.

LCDR KELLEHER

In outlining the objectives of the meeting LCDR Kelleher indicated that one of the main purposes of the meeting was to bring together the various organizations and agencies that have been working independently on computer simulation models and develop a dialogue among researchers. This objective was certainly obtained.

LCDR Kelleher made the point that he considered himself a user for the modelling effort. He felt that combat simulation models are very much a research tool in addition to their other uses. He suggested that combat models could be used to guide and structure research efforts in the future. He also questioned whether or not we had fully utilized the data that is currently available. Maybe we need to have a major effort to organize and make available the existing human performance data before we go out and collect more data.

For detailed information regarding the presentations on the individual models you should pick up a copy of the meeting proceedings. We will, however, make some very general comments about some of the generic comments that were made by the speakers.

Dr. Toms talked about Janus and suggested four essential items for a good model.

Openness - full disclosure of the models structure and content - good documentation.

Usefulness - The model should be used by individuals other than the developer. It should not be a cleaver laboratory game.

Limitations - The limitations of the model should be clearly spelled out and made available to the users.

Validation - The model should reflect what really goes on in the real world.

Dr. Toms indicated that Janus had been changed over to a distributed data processing architecture to enhance processing speed and allow the running of the model in remote locations. Dr. Toms reported that Janus included some basic human performance information, but that he considered the lack of this type of information one of the biggest short-falls in the model.

Mr. Anno described the mutidisciplinary development of Crew III and how it was a continuation of the IDP work done for the Defense Nuclear Agency. This program like many others has used symptomology descriptions to tie stress variables to performance.

The Crew III model is now being used in Janus to handle some of the human performance information.

Dr. Terhune talked about the SEES model which is a modified version of Janus that was developed for the Office of Security Evaluations. It is unique in its ability to handle combat simulation in an urban type environment. Its primary purpose is to model the problem of armed intrusion against a secure site. Dr. Terhune felt one of the main reasons for their success has been the close working relationship they have had with the security guard users. They have been intimately involved from the start.

Major Anderson is a user of computer models. He manages the Tactical Warfare Simulation (TWSEAS) unit at Camp Pendleton. His system, like the others presented, includes limited human performance information. TWSEAS is used for staff training and as such needs to be as realistic as possible. Maj. Anderson stressed, however, that the human performance inputs did not have to be perfect, an approximation of the human element would be better than what he currently has.

Dr. Klopcic described the AURA (Army Resiliency Analysis) model. Unlike the other models, AURA is a one sided model that looks at the functioning of a unit over time including times following hostile attack. AURA is designed to be a framework into which existing models can be incorporated. Dr. Klopcic referred to AURA as a methodology rather than a model. One point that Dr. Klopcic made that needs to be emphasized is that by not considering a given variable in a model does not mean that you have not included its effect. It just means you have either consciously or unconsciously assigned it a value of one.

Dr. Yencha and Dr. Kirk spoke on the NURA model which is the Navy's version of AURA. The model is primarily designed for assessing the impact of chemical attacks on naval vessels. They are looking for good human performance information for their model, more specifically, they are looking for information on the affects of MOPP gear (chemical warfare protective clothing) on performance.

Dr. Laughery devoted most of his time to "task network modelling" which is the structural technique used in the MICRO SAINT software. Dr. Laughery feels that this software can act as the bridge between human performance modelling and the combat simulation model. MICRO SAINT is a commercial product that was developed under government contract. It has been used extensively for modelling human performance, but it is general enough to be used to build any network simulation. The developers of MICRO SAINT think that it will do for modelling what the spread sheet programs did for financial analysis. Its user friendly nature will eliminate the need for a modelling specialist and bring modelling capability down to the user level.

Mr. Hawkins described the SHIPDAM model which is a modified version of the ship vulnerability model that have been developed at David Taylor Research Center over the last 15 to 20 years. Its a Monte Carlo model designed to handle probabilistic events. The model is not yet complete or documented, but is being used for several projects.

Commander Contreras discussed the R&D system and outlining the research project review process. He indicated that knowledge of this system was important for getting new initiatives such as combat simulation and human performance modelling funded. He emphasized the importance of identifying the user community early on in the development so that a transition plan can be put into place. He closed his presentation by listing the four criteria he uses in evaluating new programs.

They are:

1. A documented need or requirement and an indication that the researcher has taken the time to learn about and understand the problem.
2. A well laid-out plan with achievable goals.
3. An indication that the researcher is aware of and using all available resources: both equipment and information resources. Not just in his organization, but throughout the R&D community.
4. An understanding and support of the R&D system. For a project to develop smoothly the researcher has to know the steps involved in the R&D system.

Finally, Commander Contreras suggested that researchers working on computer systems that potentially could be used in operational medicine be aware of DAMSEA the Defense Medical Systems Support Center. It is the Department of Defense that oversees the implementation of new computer systems. He was not sure what they were doing in the modelling arena, but suggested that they be contacted.

In the general discussion session Dr. Alluisi suggested that the human performance modelling had to be focused on those tasks that make a difference in the outcome of combat engagements. He suggested that we should conduct some sensitivity studies using the combat simulation models to determine what tasks we need to model. He indicated that this information was going to be extremely important in the evaluation of weapon systems and that the science of combat simulation was going to take on increased importance in the future because it is one of the only ways you can systematically evaluate the importance of various system components.

CONCLUSIONS AND RECOMMENDATIONS

1. We really don't have a good idea of what human performance data is available for modelers and/or how useful it will be.

2. We need a list of problem areas from the modelers to help focus the human performance research effort.

3. There seems to be two points of view regarding how we should attack the modelling problem: one suggest a bottoms up approach while the other feels an top down approach is more appropriate.

   Bottoms Up - Each lab has its own particular needs and as models are built to meet these needs, they can be used as building blocks to build larger combat simulation models.

Top Down - If we wait for the development of all of these individual models we will never get to the overall model that will meet user needs. Lets get a rough cut model up and running and use it to identify information that is needed. Let the large overall model drive the research effort.

4. Hardware no longer appears to be a constraint. By using distributed data processing along with 32 bit intelligent terminals modelers seem to be able to do just about everything they currently want to do. The cloak point now appears to be the quality and quantity of human performance data available.

5. There appears to be a need to bring in funding from a number of different sources rather than relying solely on the Medical R&D Command.

6. It was suggested that we use a matrix of independent and dependent variables to relate the impact of various stressors to various performance variables. The relationships could be developed from the scientific literature and specifically designed studies. There seems to be some concern as to whether such a matrix could be translated into combat performance.

7. There appears to be a need for some sort of clearing-house for the exchange of information regarding the modelling effort. It was suggested that an electronic network be set up that includes bulletin boards and electronic mail for the dissemination of information and ideas.

8. It was suggested that a directory of modelers be developed and that it include the electronic addresses for those on the ARPA Net.

9. Several investigators felt that we need to confine, at least initially, the human performance modelling effort to the small combat unit rather than trying to introduce human performance data at the Division or Brigade level.

10. There appears to be a need to get some type of human performance information in the existing models right now. We can refine the development after we get something out there operating.

11. A publication needs to be developed that reviews the human performance literature and evaluates the models that are currently available. Something similar to what was done by LLNL for the combat simulation models.

RECOMMENDATIONS / SUGGESTIONS

1. Within the US Navy, a combat simulation integration review function is needed to provide specifications and guidance regarding the existing Navy modelling efforts. This function is needed so that greater utility for existing models can be generated. It would also allow for greater integration of existing models. Currently, there are many different machines and programs running models which cannot be easily joined together if needed. A Modelling oversight group could insure that new models conform to criteria and standards which will allow

them to be integrated in the future or at least be "modular and transportable" to other systems/models.

2. A Handbook for Combat Simulation Model Development from a multidisciplinary point of view could be very valuable in banding together professionals from the OR, Physical Sciences, Behavioral Sciences, and Engineering Communities. Lawrence Livermore National Laboratory and BDM have developed a straw-man table of contents and a suggested author list of over 30 individuals to contribute to this effort if sufficient funding from the joint services is obtained.

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A joint Navy/Lawrence Livermore meeting was held to bring together individuals from two research communities, the combat simulation and war gaming community, and the human performance community, to form an exchange of ideas and concepts with the ultimate objective of improving the fidelity of combat simulation modeling. Recommendations were to identify a limited number of existing operational models that the Naval Medical R&D Command would like to support, the number be no more than two or three; identify models and determine through sensitivity analysis which human performance elements within the model have an impact; develop priorities among the independent variable to be studied; develop a human performance matrix that relates the priority list of independent variables with the human performance variables; build MicroSAINT network models for each of the cells in the human performance variables; promote and support the development of a Handbook for Combat Simulation; and establish and support an electronic clearing house for sharing and dissemination of literature, data, and modeling results.

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