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DMSO CONSOLIDATED FUNCTIONAL WORKING GROUP WORKSHOPS REPORT

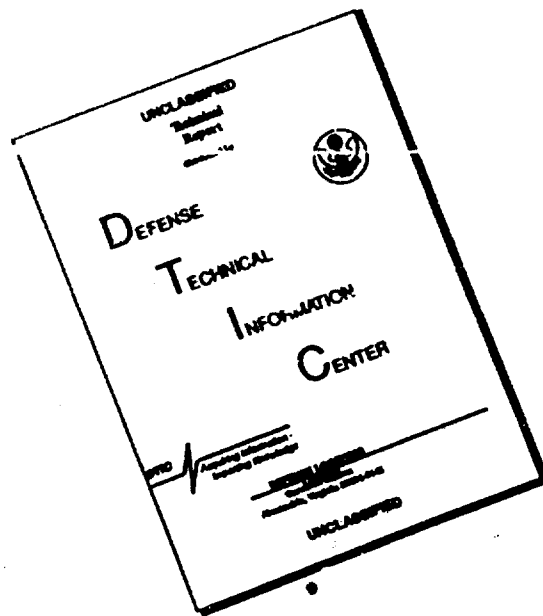
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13. ABSTRACT (Maximum 200 words) During 1992, a series of workshops was conducted in support of the Defense Modeling and Simulation Office (DMSO) to determine the modeling and simulation (M&S) needs of the defense M&S community. This community is partitioned into five major areas: Education, Training and Military Operations (ETMO), Research and Development (R&D), Test and Evaluation (T&E), Production and Logistics (P&L), and Analysis. Each of these areas has a Functional Working Group (FWG) representing its interests to the DMSO and other interested parties. Workshops were conducted to assist the FWGs in determining the "requirements pull" to be considered in the development of the DMSO Master Plan. This document provides a summary of the workshop results. The organization and procedures of the workshops are described, and an integrated summary of all five FWG's M&S needs is presented, thereby providing a concise set of high-level statements that capture the major M&S Needs identified for the DOD--as defined by the five Functional Working Groups and their workshops. Both common needs across functional areas and unique needs for each group are identified.				
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SECTION 1

EXECUTIVE OVERVIEW

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EXECUTIVE OVERVIEW

This section will present an overview of the modeling and simulation needs identified and the process used to reach them.

OBJECTIVES OF WORKSHOPS

The community that modeling and simulation (M&S) must support in the Department of Defense (DOD) is partitioned into five major areas: Education, Training and Military Operations (ETMO), Research and Development (R&D), Test and Evaluation (T&E), Production and Logistics (P&L), and Analysis. Each of these areas has a Functional Working Group (FWG) representing its interests to the Defense Modeling and Simulation Office (DMSO) and other interested parties.

To develop a DMSO Master Plan, both "requirements pull" and "technology push" perspectives must be considered. Technology Working Groups are organized to provide assessments of the state-of-the-art and to identify emerging technologies. The FWGs are to provide the "requirements pull".

The objective of the activities documented here was to develop a baseline set of needs for each of the FWGs. Both common needs across functional areas and unique needs for each group are identified. Each FWG was requested by DMSO to develop an initial statement of its community's M&S needs. In order to better reflect the diverse desires across the broad areas of interest, T&E, ETMO, P&L, and R&D conducted workshops with participants from a representative cross-section of their communities. The Analysis community, smaller and more cohesive, felt that their needs were well documented and provided a concise needs statement to DMSO; this information is also included in this summary.

The responsibilities and range of interests of these communities are changing to meet the new world conditions that the military is facing in the 1990s. New conditions include: a broader spectrum of conflict, including non-traditional missions; reduced budgets, reduced and redistributed forces, and reduction of forward deployment.

The primary objective of these workshops was to identify the M&S-related needs that each of five major DOD functional communities feel are important in the future for the successful completion of their evolving missions. An additional benefit of these workshops was to introduce the communities to the latest advances in M&S and to facilitate communication among the diverse participants.

ORGANIZATION OF THIS REPORT AND RELATED DOCUMENTS

This document provides a summary of the workshop results. The organization and procedures of the workshops are described in this section. An integrated summary of all five FWG's M&S needs is presented in the last part of this section., thereby providing a concise set of high-level statements that capture the major M&S Needs identified for the DOD — as defined by the five Functional Working Groups and their workshops.

This document also includes more detailed needs summarized from each FWG. Section 2 contains the results of the T&E workshop. Section 3 provides the results of the ETMO workshop. The P&L workshop summary is found in section 4. Section 5 contains the results summary from the R&D workshop. The Analysis needs are presented in section 6. For even more detail, the proceedings for each workshop are available in separate publications.

WORKSHOP ORGANIZATION AND PROCEDURES

The workshops were organized in a similar manner and utilized similar procedures. All workshops began with a series of informational briefings to the participants. These briefings served to define the objectives of the workshop, provide a common background understanding of DMSO's mission, highlight major new M&S activities, and describe the organization and procedures to be employed during the workshop.

Workshop products were generated in small, 10- to 15-person working groups. A chairman ran the group and was responsible for its products. A detailed sequence of activities and intermediate products were defined to develop M&S needs statements. Alternative groupings were sometimes used to allow services or other communities to discuss issues together and/or to facilitate the sharing of information.

The Interactive Meeting method served as the foundation for working group activities. This approach emphasizes a high degree of interaction between the group members and results in the development of consensus products. As part of this methodology, facilitators were present in each group to record ideas and as a general resource for the chairman. Facilitators were trained in meeting dynamics and, working with the FWG Chairmen, designed the workshops' procedures. Facilitators had no agenda of their own, but were there to facilitate the working group process.

Intermediate working group products were shared either formally in briefings or informally through public postings and/or individual discussions. The output from closely related individual working groups was then merged by their chairmen and co-chairmen, where appropriate.

Final workshop products, primarily the M&S needs, were briefed formally at the end of the workshop — often with special invitees in attendance. The individual workshop results, presented in this document, have been coordinated and reviewed by the associated FWG and, through them, other senior organizations.

INDIVIDUAL WORKSHOPS

Four workshops were held in the summer and fall of 1992. This section summarized the dates, locations, and any unique aspects of each workshop.

T&E Workshop — 26 - 28 July 1992

The T&E Workshop was held 26 - 28 July 1992 at MITRE in McLean, VA. A M&S needs survey had been done prior to the workshop, and the results served as background material and a starting point in needs development. Primary working groups were formed to develop Policy, Management and Technical needs. Service group meetings were held near the beginning and end of the workshop.

ETMO Workshop — 14 - 16 September 1992

ETMO held its workshop 14 - 16 September 1992 as an extension of the annual Joint Training Conference. Working groups for this community represented quite distinct responsibilities: Joint Training, Common Service Training, Education, and Mission Planning/Rehearsal. Working group M&S needs were not merged.

P&L Workshop — 17 - 18 November 1992

The P&L Workshop was held 17 - 18 November 1992 at MITRE in McLean, VA. Services presented their first-cut view of M&S needs as a starting point, and then production and logistics working groups developed consensus needs lists.

R&D Workshop — 2 - 4 December 1992

R&D held its workshop 2 - 4 December 1992, also at MITRE, McLean. Participants were partitioned into five R&D area working groups, and needs developed relevant to each area. Chairmen merged the needs lists after the conclusion of the formal workshop.

The Analysis Functional Working Group provided their statement of community needs in the summer of 1992.

SUMMARY OF M&S NEEDS

This section identifies the most significant and pervasive needs identified by the FWG communities. These needs are broad statements explicitly noted by particular workshops as priority needs and consistent with M&S infrastructure assumptions or expectations of future capabilities.

Satisfaction of these needs will generally involve three related components. Clear, precise policy must be developed to guide and motivate coordinated actions. Management must consistently demand adherence to coordinating policy and insist on the best technical solutions. The appropriate technology must be developed to allow specific needs to be addressed. Some needs clearly call for solutions that will rest primarily on one of these components, but each need should be considered from all three perspectives.

Table 1-1, on the next page, summarizes the needs explicitly identified as high priority for the individual functional communities. A general consensus exists across all communities on the desirability of all 17 needs; some were generally assumed to be present in the future and therefore not explicitly called for in final results, while others are not considered as high a priority.

A number of these needs are related to each other, and their satisfaction would be linked. Standards and Commonalty, Data Bases, Models and Simulations, Scenarios, Tools, Information Sharing and VV&A are closely related. These individual needs really compose a larger need for easily accessible libraries of data, models & simulations, scenarios and related tools. The information on what is available needs to be shared and the products in these libraries need to be VV&Aed to a high degree. The potential for constructing these kind of libraries is based on adherence to standards. All these products are needed to provide truly efficient modeling and simulation.

The needs for Education of Managers and Education of Practitioners are closely related, both the practitioners of modeling and simulation and the consumers of these activities must understand the technology and how best to utilize the many options available. Also related is the need for M&S Policy Statements that would define the basic ground rules for the application of these skills.

Table 1-1. Summary of M&S Needs by Community

	T&E	ETMO	P&L	R&D	Analysis
1) Standards & Commonality	X		X	X	X
2) Data Bases	X	X	X	X	X
3) Models & Simulations	X	X		X	
4) Scenarios		X		X	
5) Tools		X		X	X
6) Information Sharing	X	X		X	
7) Interoperability	X	X	X		
8) Networks	X				
9) VV&A	X			X	X
10) Multi-level Security	X	X			
11) M&S Policy Statements	X		X	X	
12) Education of Managers	X	X			
13) Education of Practitioners	X	X			
14) Environmental Representation		X		X	X
15) Behavioral Representation		X			X
16) M&S Development Environment	X			X	X
17) New Models & Simulations		X	X		X

The 17 areas of need are listed below, with the numbers for reference only and not indicating any particular ordering or prioritization.

1) Standards and Commonalty

Background

With the decreases in DOD funding and the multiplication of new military roles and missions, much more efficient and flexible simulation development must be accomplished. In the past, each service and, often, each organization developed M&S capabilities essentially from the ground up. In addition, these models and simulations could not effectively work with other software, and data typically required unique formatting and preparation. These factors contributed to generally expensive and inflexible products, whereas support for the rapidly evolving joint and non-traditional missions are not getting adequate M&S support.

Need

The need for standards and a commitment to commonalty is broadly recognized as vital for realizing the most flexible, functional, and cost-effective M&S capabilities. Without standards, little commonalty or reuse would be possible. The value of standardization is evident for both M&S construction and use of existing components. Standards should apply to data bases, M&S, interfaces, scenarios and tools. This need encapsulates the broad recognition that a higher degree of cooperation and enforcement must be exercised.

Several specific needs could fall into this category. A commitment to a common open systems architecture or set of related architectures is needed, with its associated standards and protocols. A further need is for a more effective software development language, accomplished through either improvements in Ada or routine waivers of its use. Standardization should reach beyond the DOD, into other government activities, the commercial world, and into international standardization organizations. Not only must standards be defined, but some capability to enforce conformance to those standards will also be needed.

2) Common Data Bases

Background

The continuing difficulty of finding and then using quality data for many M&S purposes is widely recognized throughout the community. Extensive, representative data is difficult to collect and transform into a usable data base; and the fact that most good data bases that do exist are unknown to the many activities that could productively leverage that data results in a great deal more expense, delay, and often project failure.

Need

Well-accepted data bases that are in a generally usable format and available in some sort of a accessible libraries is a pervasive need. Many specific kinds of data are needed, but the primary point is that it be good, accepted data (developed, verified and maintained by the appropriate organization) that can be easily located and acquired. Data bases are needed that are geographically global in extent and cover a wide range of subjects. The data bases should use real-world data that is continually updated to reflect changing situations. Not only must these data bases be made available, but specific organizations must be charged with their continued refinement and accreditation. The Defense Mapping Agency (DMA), as the source of well defined terrain data, is a good example of a successful approach; other data areas that would be equally well served by common accredited data bases could be enemy forces, military equipment performance, and atmospheric data. Related to the availability of these data bases is the associated need for collection capabilities, particularly from real-world sources such as test ranges and training exercises.

The sources and history of assumptions used to develop the data bases are as critical as the data itself; therefore, the data bases must be traceable to the data source to allow verification of the applicability of the data.

3) Common Models and Simulations

Background

Similarly to the previous discussion, models and simulations are developed and retained with very little coordination across activities. Expensive, duplicate development efforts are often undertaken even though existing M&S match the essential functionality required.

Need

Libraries of common, verified models, and simulations including component parts are a major need. Models needed throughout the DOD may have even greater variety than the underlying data needs, and therefore M&S development will remain a significant activity. In order to realize the potential for M&S commonality and reuse, the products in question must be designed with ease of use, flexibility, and modularity in mind. Standardized, validated component part models that could be assembled into larger systems and logistics simulations that could realistically represent this area are only two examples of M&S that would draw great interest in many communities. Common multispectral environmental and electromagnetic propagation models were other examples cited, as was the need for a foundation level model of human behavior and decision making.

Families of well accepted, verified, and validated models should be available that could be easily accredited for a particular type of use. Models and simulations should be built in adherence to an open system architecture and standard interface protocols. Data could then be imported from and exported to standard data bases. Configuration control standards should also be applied. In addition, improvements in the Ada programming language should be made to better support M&S development.

4) Scenarios

Background

Military roles and missions, as well as the associated context, are the central drivers of many activities, and they are changing dramatically. Significant practical problems exist in finding specifications of currently relevant and accredited scenarios at the level of detail required to support many activities. Even when the important details of a scenario can be determined, often from many sources, the assemblage of this material into a scenario data base is a very expensive operation — often requiring hand loading a large data base.

Need

The need for scenarios elicited two related needs: a library of approved and maintained scenarios and a scenario generation tool. This is more a matter of degree, as most scenarios would begin with some kind of a well-founded starting point and then need some efficient method of modifying it to fit its exact use. The target capability desired is for a highly automated tool that would draw on approved data bases of scenario information and lay down or construct a scenario as needed. An automated scenario generation tool would reduce the labor requirements to create a scenario and increase the fidelity of scenarios while maintaining traceability back to data sources and assumptions. As the roles and missions evolve and expand, it is vital that acceptable scenarios can be efficiently developed to form the basis of study, testing, and training.

5) Simulation Data Tools

Background

M&S generates and requires handling of large amounts of data. This information must often be analyzed or parts used to rerun/play back the simulation. This data serves as a prime component of after action reviews and must be available in a meaningful form very soon after the event to be of any use. Tools for handling simulation data are needed for activities such as analysis studies, training activities, and after action reviews.

Need

More effective and easier-to-use simulation data collection, analysis, and display tools are needed. These tools would be related to the specific M&S in use to some degree, but through adherence to M&S output standards could be flexible and general purpose. These tools would include capturing of simulation data into an efficient archive, analysis of large amounts of data, and flexible visual display of analysis results. The M&S user may need the capability to "playback" a particular part of the simulation activities. Particularly for analysis and display, existing commercial products could fill a large proportion of the need — with some specialized interface construction. One other area needing tool support is exercise or distributed multi-simulation management, closely related to network management problems.

6) Information Sharing

Background

In spite of the vast array of models, simulations, data, and scenarios that exist throughout DOD and would be very useful to other organizations, those opportunities are rarely taken advantage of because the existence of an item of interest is very unlikely to be known outside its immediate activity. Even if knowledge of something has seeped out, the details required to make a firm judgment of its utility are rarely available. Not only are existing products not leveraged as fully as possible, the cumulative DOD experience and knowledge in using various M&S products and methods is not efficiently disseminated.

Need

To more effectively leverage existing products, reduce duplication, and overcome the many often frustrating roadblocks in a complex M&S based endeavor, the easy information sharing is needed. Many diverse ways of sharing information are possible, from on-line product libraries through focused users groups. Ease of access to the information is a major factor. Establishment of an M&S information clearing house with free and easy access to data would be an excellent early step. Users' groups, especially joint service groups should be encouraged. This sharing of information would be synergistic with the development and standardization of the products themselves.

Individual services should consider establishing an M&S focal point to coordinate all M&S efforts. Centers of excellence could be built to encourage M&S technology development.

7) Interoperability

Background

Past simulation products have been developed as stand-alone systems that may adequately address their design goals, but can be used together only with the greatest difficulty. The increased prominence of joint operations requires the use of the preferred simulations from different services and branches. There is high interest in combining the new virtual simulations with conventional constructive wargames and live vehicles on ranges to gain maximum benefit from the capabilities available. The scale and type of desired operations to be simulated spans from special operations to mid-high intensity warfare. Finally, the increase in training and testing value for incorporating real-world command, control, and communications (C3) equipment into simulation activities is well recognized.

Need

The overriding need that addresses these issues is for interoperability. Interoperability of virtual, constructive and live systems including C3 equipment is needed. Both vertical (across levels of detail) and horizontal (across functional areas) integration is needed; this would weld all services and branches into a unified, interacting whole that could be used to represent any scale or type of operation. For instance, new weapons concepts could be virtually prototyped and their combat utility investigated on the dynamic battlefield. Joint command post exercises could represent each facet of the action as appropriate for the participants and incorporate detailed play of critical small scale actions.

An open system architecture that allows distributed and interoperable M&S is needed to support the wide diversity of military operations. M&S capabilities are expected to develop as separate modules, such as command post simulations, weapon platform simulations, and environmental simulations. An open system M&S architecture will allow M&S capabilities to be combined as necessary to provide the tool needed.

8) Networks

Background

The desire to use M&S is spreading rapidly, as is the need to interoperate with many different components. To fully realize the efficiencies of the interoperating, simulation-based capability described in the previous section, the networking connectivity must be in place to support it. This becomes more significant as the numbers of participants increase, and as combined arms and joint activities require many different components to operate together. Too often, gaining reliable network connectivity to support a given activity becomes a major effort that must be planned well in advance and does not easily allow much flexibility. Both simulation interactions and participant communications must be supported.

Need

An established and permanent network capability, dedicated to simulation related activities and capable of supporting distributed, real-time processing with man-in-the-loop and/or hardware-in-the-loop, is needed; one that will connect all potential participants and developers into one large, flexible community. Data linkage is needed between subsurface, surface, air, and space systems. This would allow units to train with their widely dispersed task force components without leaving their home station. Virtual, constructive, and live practitioners and developers should be reliably and flexibly connected. This network infrastructure should support both interoperability and video telecommunications.

The network must include management features to facilitate its efficient use, including asset readiness checking, standardized cost procedures, adjustable data rates, minimum latency, and on-line context-sensitive help. Network reconfiguration and traceability must be supported.

9) Verification, Validation, and Accreditation (VV&A)

Background

Increased reliance is going to be placed on M&S in support of all DOD functional communities, with critical decisions based on their results, particularly in areas such as testing and concept evaluation. This places increased importance on the issue of VV&A. While some service policies have been written, a great deal of confusion remains in the user community. Generally, accreditation reviews, when done, are informal or lacking clear guidelines; and the applicability of previous accreditation to a new M&S use is unclear. Verification is part of any software development process, but the rigor in which it is applied usually does meet that desired; better automated tools would prove a significant help. Validation is rarely performed except on small, very precisely defined and critical models. The practical difficulties of accomplishing V&V usually result in it not being effectively done. The M&S user must have the tools available to at least be satisfied that the M&S that is being used is credible.

Need

The M&S community needs to have a consistent and realistic DOD policy for VV&A. Standards and guidelines for VV&A must be developed. This would have to include clear specifications of who is responsible for what VV&A activity when, and define issues like assumptions and tolerances. Good definitions of exactly what is meant by VV&A must be provided so the user can determine which level in the process can be achieved. In addition, as soon as a M&S tool is modified it will require VV&A to ensure the results are appropriate for comparison to results from other programs and projects. One reason this has not been better done in the past is the complexity and cost associated with dramatically better VV&A. Automated V&V processes and support tools must be developed to realistically conduct VV&A at the level required in the future.

Increases in adherence to commonality standards and communication across services and functional areas could allow establishment and usage of common/shared test data for validation of common models and simulations.

10) Multi-Level Security (MLS)

Background

The expanding participation in large simulation-based activities, including allied combined operations, and the desire to incorporate classified and even compartmented products into many of these activities raises obvious security problems. Desert Storm demonstrated the value of highly classified imagery available at the tactical level, and also the need for commanders to exercise with all the information they would have available in action. Leveraging on-going training activities to examine effects for classified equipment could present additional security problems. Any attempt to make data, M&S, and scenarios broadly available for examination and use would present more security complications.

Need

For the above and other reasons, a MLS capability is needed for the distributed, interoperable simulation world. This capability is also needed for effective exchange of information and M&S-related products. Selectable transparency is needed into data of multiple levels of classification to allow viewing of the most informative information possible at a given level of classification. It is recognized that MLS is a very difficult problem throughout the DOD and that solutions will likely be developed working closely with other government agencies and commercial system developers. Particular attention must be placed on MLS capabilities and performance parameters in networks, operating systems, data base management systems, and high-speed encryption/decryption.

11) M&S Policy Statements

Background

Particularly in acquisition-related areas, M&S's potential is very often not realized. Often M&S is not used at all, or if it is, unrealistic demands are made of the technology without incorporating it into the process at an early stage where its results could constructively help in providing a better product. Too often, funding for M&S is the first item cut.

Need

As the potential benefits of more sophisticated and pervasive M&S will be growing, DOD policy statements are needed to ensure early involvement of M&S in the acquisition cycle and demand appropriate M&S-based products as part of the process. This need includes specific guidance on where, when, and what kind of M&S should be used throughout the acquisition cycle and after deployment in training.

On a more general level, most of the needs identified by the DOD communities will require policy statements to facilitate adherence to standards, elimination of duplication and consistent follow-through. For instance, general requirements (responsibilities and guidelines) for VV&A of models, simulations, and associated data bases prior to their use are needed. Policy should enforce conformance to international and DOD standards.

Associated with a more consistently defined role for M&S must be reliable resource and funding support for its activities. Centralized M&S "advocates" are needed to coordinate and represent a community's funding requirements.

12) Education of Managers

Background

Program managers and other decision makers often do not have a good understanding of computer M&S. This can lead to disuse and misuse of M&S. M&S can be a particularly effective tool early in the acquisition and design process where product changes can be inexpensively made; too often, program managers do not realize or take advantage of these opportunities.

Need

There is a need for better education of managers about M&S, and to raise their awareness of the most important issues concerning its use. This includes the benefits available from using M&S and the different types and methods of applying M&S. Program managers need to understand the advantages and disadvantages of different modeling and simulation approaches and the analysis techniques they support. Other issues deserving emphasis would be the importance of modeling assumptions, the process' reliance on sound data and appropriate statistical techniques. Better informed decision makers would facilitate the advantageous application of M&S and ensure that this technology is appropriately applied with realistic expectations. If program managers do not understand M&S, the door is wide open for its under utilization or misapplication.

A basic understanding of M&S and its managerial implications should be a part of professional military and DOD civilian education, at institutions such as the Defense Acquisition University.

13) Education of Practitioners

Background

One of the most fundamental building blocks for the effective and efficient application of M&S is the skills of the individuals directly building, using and overseeing M&S. M&S is generally not an academic discipline and training in its methods and techniques is inconsistent and often haphazard. This is often the case for M&S developers, users of analytic models, and government and non-government supervisors of these activities.

Need

There is a clear need for education, training, and career encouragement for M&S practitioners. The skills to be addressed would include such things as understanding the advantages and disadvantages of different modeling techniques, experimental design and statistical analysis of data. Needed skills range from the application of specific simulation programming languages through disciplined VV&A procedures. Forums for the exchange of information on M&S and to "publicize" work being done is needed within functional areas and across DOD.

In addition, some kind of M&S-related career path for civilian and military personnel would encourage the increased professionalism and expansion of knowledge. Establishment of a secondary military specialty to ensure the availability of personnel with in-depth M&S expertise should be considered, and M&S skills should be included as part of early professional military education.

14) Environmental Representation

Background

While some environmental factors, such as static natural ground terrain, are fairly well represented in current M&S for selected areas, many other dimensions are only modeled in a rudimentary way and detailed data has only been collected for small areas of the earth. Other domains, such as the atmosphere and the oceans, need better modeling of their behavior and a great deal more data collection. The dynamics of the environment also must be more accurately modeled, whether on the battlefield or during natural disasters. Currently, most simulation-based analyses and almost all training are conducted in essentially perfect weather in traditional battlefields of temperate climate.

Need

Improved environmental representation is needed to allow the sophisticated and wide ranging M&S desired by all communities. This need entails much more detailed data on the environment and a great deal more coverage of the globe. Environmental representations need to be developed for an increased spectrum of phenomena, including the full range of natural (e.g., weather, light, and thermal conditions) and manmade (e.g., electronic warfare (EW) and other electro-magnetic emissions) environments. While data may be the most pervasive aspect of this broad need, standardized algorithms and models of environmental effects on sensors and systems must be incorporated into models and simulations. Both data and environmental models would be excellent candidates for inclusion in common libraries.

15) Behavior Representation

Background

M&S, especially if it is done with any level of detail, has usually required large numbers of personnel or players — each in essence supplying the decision making C3 for the forces under control. An individual can reasonably only experience and realistically respond at one level of command at a time, with a somewhat greater span of control practicable than in the real world. Especially in the realm of command and control, (C2) tradeoff choices are usually demanded between number of participants/controllers and realistic representation.

Need

More realistic representation of military behavior generally, and decision making in particular, is needed. Fuller understanding of this phenomena and more accurate simulation representation of this behavior is needed to provide a more realistic opposing force, extend the battlefield for friendly higher, lower, and adjacent forces, and to have these forces react to battlefield dynamics in a realistic manner. M&S would rely on far fewer supporting players, and a more flexible simulation environment would be provided. The M&S practitioner could choose from "playing the computer" with intelligent forces (IFOR), limited direction or input from the operator with semi-automated forces (SAFOR), or replacing behavioral representations with man-in-the-loop.

Improved behavioral representation would allow the broad applicability of approaches based on distributed interactive simulation (DIS), that require resolution to the platform level, to be applied to the problems and staff structures of all communities. The behavior of enemy, friendly, staff, support, civilian, and other agency entities must be understood and represented in M&S environments — this would enable simulations to be configured to match the participants resources and desires and still provide a realistic setting. Behavior representation and modeling of C2 requires both more basic research and the creative application of current knowledge. This need will prove one of the most challenging to fulfill, demanding disciplined research, but also one that must have significant progress made before M&S can approach its potential throughout DOD.

SAFOR is in the early stage of development, primarily serving as an efficient (if not particularly challenging) opponent. True Intelligent Forces (IFOR) and general Computer Generated Forces (CGF) are needed for more realistic portrayal of enemy forces and reasonable substitution for human participants.

16) M&S Development Environment

Background

Analytic models and simulations must often be built or modified by analysts to explore specific evolving issues. The scope of issues to be studied and the pace of evolution in the world situation demands many new and enhanced M&S. Currently these development activities are done with a wide variety of supporting software and simulation development tools. These tools are often minimal and because of their diversity can not facilitate reuse of their products. The resulting M&S development will take longer, cost more, contain more errors, and prove less valuable for addressing future problems than if a unified state-of-the-art development environment were in use.

Need

The M&S development community needs an advanced M&S development environment. This is essentially a suite of software development tools, perhaps several sets optimized for development of specific M&S types. On one end of the spectrum of environments could be an analysis model construction set to allow quick assembly of accepted component modules — on the other end would be a software development environment allowing construction of detailed simulation components. An advanced set of tools would make development more efficient, and reuse could also benefit through encouraging commonality.

Examples of tools desired by workshop participants include: visual programming capability and automated documentation tools. These tool set environments would be designed to support a standard software development methodology, providing an interoperating suite of tools that support all phases of the M&S development process.

17) New Models and Simulations

Background

The roles and missions of the services are expanding rapidly and the range of likely environments in which they would have to operate is broadening greatly. The DOD will be placing considerably more reliance on M&S for training and analysis. While not a primary objective of these workshops, a number of new areas that must be modeled and simulated are identified, including existing areas that demand new depth. Also mentioned are new characteristics for simulations in general.

Need

Significant new M&S functionality is needed; these would be accomplished through both enhancements to existing capabilities and totally new M&S developments. M&S coverage of the complete spectrum of evolving military operations in all regions of the world is needed. This includes non-combat missions such as nation building, disaster relief and humanitarian assistance, with more varied participants including joint and coalition forces, and localities, such as Somalia and the Balkans. Models of social, economic and political interactions are needed for training, education, and analysis. These simulations would be multi-sided, with the differing national goals and objectives of the participants realistically represented.

Other areas, currently abstracted in most simulations, must have a higher level of resolution; for instance, to illustrate the vital role of logistics and its dynamic influence on all other activities. The usual scenarios and the simulations that use them must be broadened to include activities leading to and following the traditional M&S focus of force-on-force combat; the inclusion of mobilization and deployment activities is a good example.

The community needs the seamless integration of a number of specific focus areas and their associated models and simulations in order to realize the broad and complete representation of these complex events. The integration of intelligence and its source agencies' operations is one of the most challenging areas to be accommodated.

More specifically, needs were identified for specialized M&S based decision aid tools to address particular issues. These tools could include those for: commander-in-chief (CINC) operations plan (OPLAN) planning and execution, force sizing and unit realignment impact evaluation, acquisition modeling, logistics budgeting, alternative materiel management, NDI/COTS performance analysis, Integrated Product and Process Development, and DOD remanufacturing and repair. General purpose components that would enhance many simulations and be prime candidates for commonality and reuse are needed, for example, multi-spectral scene generators.

Some fundamental changes in the way most models and simulations are conceived and designed may also be needed to more accurately represent world situations and provide vehicles for training and analysis. An example of the far-reaching changes in philosophy that may be needed could be situations that are more than two sided.

SECTION 2

TEST AND EVALUATION WORKSHOP SUMMARY

SECTION 2

**TEST AND EVALUATION
WORKSHOP SUMMARY**

INTRODUCTION

The Defense Modeling and Simulation Office (DMSO) sponsored the Test and Evaluation (T&E) Modeling and Simulation (M&S) Workshop, reported in this document, as a forum to identify T&E M&S requirements.

The vision for M&S support to T&E is to make combat system development and testing significantly more cost-effective. By 1998, both development and operational testing will consist of significantly more simulation and significantly less hardware and/or field testing. Virtual reality will be a reality. Much of the T&E of aircraft, ships, and armor will take place in the hanger, at the dock, and in the tank park. M&S will have the credibility so that decisions can be based on simulation results that are verified by limited field tests.

A basic infrastructure will be developed to support integration of M&S into T&E community activities. System-level M&S will grow with the system during the development and acquisition cycle. The system-level simulations are expected to "net" with other systems or simulations. System plans will include M&S for development, T&E, production and logistics, and training.

Common architectures, standards, and protocols will permit the interoperability of T&E models and simulations.

It is hoped that the results of this workshop will support the development of a rationalized M&S development plan that will bring about the "vision" of M&S support to T&E quickly and cost effectively.

BACKGROUND

- **T&E M&S Workshop is one of five workshops sponsored by the DMSO**
- **Invitation to the T&E M&S Workshop from the Director, T&E, and the DMSO**
- **Participants of the T&E M&S Workshop identified actions required to produce better M&S support to T&E**
 - **Policy actions**
 - **Management actions**
 - **Technical actions**

BACKGROUND

The DMSO sponsored the T&E M&S Requirements Workshop as one in a series of workshops in five functional areas (Education, Training, and Military Operations; Research and Development; Test and Evaluation; Production and Logistics; and Analysis). The output from this workshop will be used by the Test and Evaluation Functional Working Group to guide the DMSO in promoting the effective and efficient use of modeling and simulation in the Department of Defense.

The Defense Director, T&E, and the DMSO invited the Services to provide suggested attendees to the T&E M&S Requirements Workshop.

Participants were asked to identify and prioritize policy, management, and technical requirements. Requirements addressed activities that should be funded now and those that should be funded in the future.

A consolidation of all M&S policy, management, and technical needs is provided in appendix A. (The appendices referred to in this section are contained in the individual workshop report.)

The list of workshop participants is presented in appendix B.

The workshop was conducted 28-30 July 1992 at The MITRE Corporation facilities in McLean, VA.

An outbriefing was provided to the service principals and agencies and the Director, T&E on 30 July 1992.

A briefing was presented to the Senior Executive Service (SES) Executive Review Committee on 9 September 1992.

T&E WORKSHOP OBJECTIVES

- **The primary objective of this workshop was to develop a prioritized set of T&E community needs for M&S support**
- **An additional objective was to allow users from throughout the T&E community to exchange information and develop a shared view of the future**

T&E WORKSHOP OBJECTIVES

The objectives of the workshop were as stated above.

WORKING GROUP PROCESS AND PRODUCTS

— WORKING GROUPS —

- **Day 1, Session 1: Service groups**
 - **Army**
 - **Navy**
 - **Air Force**
 - **DOD agencies**
- **Day 2, Sessions 2 and 3: Functional area working groups**
 - **Policy**
 - **Management**
 - **Three technical groups**
- **Day 3, Session 4: Two combined groups**
 - **Policy and Management**
 - **Technical**
- **Day 3, Session 5: Service groups**
 - **Army**
 - **Navy**
 - **Air Force**
 - **DOD agencies**

WORKING GROUP PROCESS AND PRODUCTS

— WORKING GROUPS —

Working groups were organized to represent service and agency views, then to obtain functional perspectives of policy, management, and technology requirements. To ensure that the end user of M&S for T&E was not lost, service and agency groups reviewed the workshop results in the last session.

WORKING GROUP PROCESS AND PRODUCTS

— SESSIONS —

- **A sequence of intermediate products was defined that lead to the final workshop report**
- **Session 1: Service visions of future T&E most effectively and efficiently utilizing M&S**
- **Sessions 2 and 3: Integrated service visions and elaborated needs**
- **Session 4: Policy, management and technical prioritized set of needs and final briefing**
- **Session 5: Service discussions, impacts, and recommendations**

WORKING GROUP PROCESS AND PRODUCTS

— SESSIONS —

The purpose of Session 1 was to allow individual services to meet and articulate their views of future M&S support of T&E. The service and agency "vision" reports are provided in appendices C through F.

Sessions 2 and 3 had functional groups that addressed policy, management, and technology capability needs in light of the service and agency views presented in Session 1. The FWG results are provided in appendices G through K.

Session 4 combined the Policy and Management groups to reach consensus on needs and prioritization of those needs. The Technology groups were merged to reach requirements and priorities for technology needs. The reported Policy and Management needs are included in appendices L and M. The reported Technical needs are provided in appendix N.

Session 5 provided service and agency review of the policy, management, and technology needs reported out of Session 4.

WORKING GROUP PROCESS AND PRODUCTS

— GROUPING OF ACTIVITIES —

- **DMSO**

**Activities that should be performed by and/or funded by DMSO —
T&E community should take advantage of (leverage) DMSO actions**

- **T&E community**

**Activities that should be performed separately by the T&E
community or through the DMSO process**

- **Services/agencies**

**Activities that should be performed within and/or funded by each
service and agency — T&E community should take advantage of
(leverage) service/agencies activities**

- **DARPA, DISA, DMA, and NSA**

**Activities that should be performed and/or funded by the appropriate
agency — T&E community should take advantage of (leverage)
activities performed by the agencies**

- **Private industry**

Activities that should be leveraged by the T&E community

WORKING GROUP PROCESS AND PRODUCTS

— GROUPING OF ACTIVITIES —

The Senior Executive Panel's review identified the action organization or group that would have to implement the identified action. This slide highlights the expected activity relationships.

Within the summary of results, these organizations are identified by each action or requirement to increase the effective utilization of M&S in T&E.

Note that funding for private industry is not implied. Private industry actions are assumed to occur as a part of the development of new products for the marketplace.

WORKING GROUP PROCESS AND PRODUCTS

— TYPES OF ACTIVITIES IDENTIFIED

IN SENIOR EXECUTIVE PANEL REVIEW —

- **Policy actions**
- **Management actions**
- **Technical actions**

WORKING GROUP PROCESS AND PRODUCTS
— TYPES OF ACTIVITIES IDENTIFIED
IN SENIOR EXECUTIVE PANEL REVIEW —

Three categories of actions were identified by the senior executive panel. These were policy, management, and technical actions. Each action type is identified in the script of the summary of results below. Policy actions are identified by (P), management actions by (M), and technical actions by (T).

SUMMARY OF RESULTS

SUMMARY OF RESULTS: VERIFICATION, VALIDATION, AND ACCREDITATION (VV&A)

- **DMSO should support the development of better VV&A tools**
- **The T&E community needs to take leadership role in VV&A of current M&S**
- **Each service should establish its VV&A requirements for T&E**

SUMMARY OF RESULTS:

VERIFICATION, VALIDATION, AND ACCREDITATION (VV&A)

DMSO needs to:

- (M) Support the development of automated V&V processes and support tools, and support the development of VV&A processes that stress both stand-alone and interoperable distributed simulations

The T&E community needs to:

- (M) Take a leadership role in the development of standards and guidelines for VV&A of models and simulations used in the T&E community and coordinate across the services
- (M) Support the establishment and usage of common/shared test data for validation of common models and simulations
- (M) Support the VV&A of existing models, simulations, and data bases to be used as standards for T&E applications

Each service and agency should:

- (P) Develop/establish general requirements (responsibilities and guidelines) for VV&A of models, simulations, and associated data bases prior to their use in T&E
- (M) Establish a VV&A process that provides documentation, configuration management, and shared information

SUMMARY OF RESULTS: STANDARD M&S AND STANDARD DATA BASES

- **DMSO should support development of M&S standards and require approved architectures, standards, and protocols for future joint M&S**
- **DMSO should demand improvement in Ada or take action to adopt another language for use in M&S**
- **The T&E community needs to support the development of standard M&S functional area models**
- **Each service should implement and enforce the use of M&S standards for T&E**

SUMMARY OF RESULTS:

STANDARD M&S AND STANDARD DATA BASES

The DMSO should:

- (P) Require all joint M&S be developed using DMSO-approved common, open-system architecture, with associated standards and protocols
- (P) Require that all future joint M&S have the capability to import data from and export data to standard data bases (e.g., DMA terrain data bases)
- (P) Require that configuration control standards, practices, and procedures be applied to M&S used in T&E.
- (M) Support the development of M&S standards and the coordination of those standards across the DOD, especially with respect to architectures, interfaces, data bases, definitions, and documentation
- (M) Support the development of standard interfaces for selected classes of models to promote interoperability and reusability
- (M) Demand improvements in the Ada programming language to better support the M&S requirements, or take action to adopt another high-order language for use in M&S
- (M) Support appropriate waiver to Ada whenever other languages meet requirements and Ada does not
- (M) Support the development of a select few models and simulations to demonstrate the effectiveness and efficiency of those models built to meet DMSO standards

The T&E community needs to:

- (M) Support the development of standard functional area models such as common threat, terrain, multispectral clutter, environmental, EM propagation, human behavior, and T&E specific applications

Each service and agency should:

- (P) Require the use of standard data definitions/elements/formats/interfaces (as they are developed) in all future models, simulations, and data bases; and encourage their use in existing models, simulations, and data bases
- (P) Require the use of standard data bases as they are developed (e.g., intelligence, terrain, atmosphere, and climate) in future models and simulations and encourage their use in existing models and simulations
- (P) Require that models and simulations meet established standards and metrics
- (M) Implement M&S standards and enforce those standards on models and simulations to be used in T&E, especially with respect to architectures/interfaces, data bases, definitions, and documentation

SUMMARY OF RESULTS: EDUCATION

- The T&E community needs to provide educational opportunities for T&E practitioners, the acquisition work force, and decision makers on the application of M&S to T&E

SUMMARY OF RESULTS:

EDUCATION

The T&E community needs to:

- (M) Provide forums (e.g., symposia and technical meetings) for exchange of information on M&S and to "publicize" work being done in segments of the T&E community
- (M) Provide M&S courses to M&S practitioners in T&E, e.g., through the Defense Test and Evaluation Professional Institute (DTEPI)
- (M) Through the Defense Acquisition University, educate the acquisition work force and decision makers on the utility of M&S for T&E

SUMMARY OF RESULTS: INFORMATION SHARING

- **DMSO should require a M&S library to support T&E across the DOD**
- **The T&E community needs to support information sharing on M&S support of T&E — this should include establishing M&S user groups**
- **The services should provide centralized coordination of the T&E M&S efforts**

SUMMARY OF RESULTS: INFORMATION SHARING

The DMSO should:

- (P) Require that information on Joint models, simulations and data bases be entered into a M&S library for sharing across the DOD
- (M) Establish a M&S information clearinghouse with free and easy access (library and Bulletin board)

The T&E community needs to:

- (M) Encourage the establishment of T&E M&S users groups, especially joint service groups, using such means as TECNET and video teleconferencing
- (M) Facilitate the communication of new technology between M&S developers and T&E practitioners

Appropriate Defense agencies must:

- (M) Facilitate communication of new technology between M&S developers (e.g., DARPA) and T&E practitioners

Services need to provide:

- (M) Centralized coordination of M&S development and applications, and allow for decentralized execution of the M&S activities

Services and agencies need to:

- (P) Establish a M&S focal point to coordinate all M&S efforts — particularly T&E policies and expenditures of funds
- (M) Encourage and coordinate M&S technology development at specific centers of excellence
- (T) Develop methodology to link analyses of combat effectiveness (e.g., COEAs) and T&E (including M&S for T&E, e.g., linkage between common, testable measures of effectiveness (MOEs) in COEAs and measures of performance (MOPs) in testing — with feedback)

SUMMARY OF RESULTS: NETWORKS AND JOINTNESS

Networks

- **DMSO should support the development and use of distributed, real-time processing with man- or hardware-in-the-loop capability**
- **Defense agencies, with requirements from the T&E community, need to provide the network capabilities to link sub-surface, surface, air, and space systems**

Jointness

- **DMSO is to encourage development of M&S that incorporates both vertical and horizontal integration and encourage new M&S development be compatible with network protocols**
- **Services are encouraged to use M&S that are capable of simulating joint operations**

SUMMARY OF RESULTS:

NETWORKS AND JOINTNESS

NETWORKS

DMSO should support:

- (M) Development/use of distributed, real-time processing with man- and/or hardware-in-the-loop capability

The T&E community needs to:

- (M) Coordinate data network requirements from the T&E community with DARPA

Appropriate Defense agencies need to provide:

- (T) Technology which permits high data-rate over a wide-area network (e.g., DSI) using embedded multi-level security techniques
- (T) Technology which permits data linkage between sub-surface, surface, air and space systems
- (T) An on-line, knowledge-based asset manager for DSI network
- (T) Modifications to the DSI network to allow reconfiguration with traceability
- (T) Improved data network capabilities in the areas of asset readiness check, standardized cost procedures, adjustable data rates, minimum latency, and on-line context-sensitive help

JOINTNESS

DMSO needs to:

- (P) Encourage developers of M&S to accommodate vertical and horizontal integration (e.g., Aggregate Level Simulation Protocol)

Services and agencies need to:

- (P) Encourage development of models and simulations that are capable of simulating joint service operations or that are interoperable with such simulations in order to assess the contributions of weapon systems within the joint operations environments

SUMMARY OF RESULTS: MULTI-LEVEL SECURITY AND PLANNING FOR THE USE OF M&S

Multi-level security

- The T&E community needs to work with appropriate Defense agencies to determine security requirements for T&E M&S

Planning for the use of M&S

- DMSO needs to provide M&S cost effectiveness data and metrics to support use of M&S
- Services should require T&E personnel involvement in the development of a system M&S plan between milestones 0 and 1

SUMMARY OF RESULTS:

MULTI-LEVEL SECURITY AND PLANNING FOR THE USE OF M&S

MULTI-LEVEL SECURITY

The T&E community needs to:

- (T) Determine requirements for multi-level security for M&S

Appropriate Defense agencies must:

- (M) Support the T&E M&S community requirements to develop multi-level security capabilities to ascertain if these efforts will meet the following needs of the T&E M&S community: networks, operating systems, data base management systems, and high-speed encryption/decryption

PLANNING FOR THE USE OF M&S

DMSO needs to:

- (M) Develop data and metrics on the cost effectiveness and other benefits of M&S in T&E

Each service and agency should:

- (P) Require the establishment of a M&S plan between milestone 0 and milestone 1 and require T&E personnel be involved in preparation of the plan; and review and update the plan for use of M & S at each milestone
- (M) Give M&S appropriate consideration and priority in the resource allocation process

SUMMARY OF RESULTS: M&S DEVELOPMENT

M&S Development

- **DMSO is to support the use of M&S in T&E by supporting advances in software**
- **T&E should encourage the development of models and simulations that are capable of real-time T&E applications**

SUMMARY OF RESULTS:

DEVELOPMENT

M&S DEVELOPMENT

DMSO needs to:

- (M) Support the development of software tools that provide the following capabilities:
- Visual programming
 - Visualization/imaging virtual reality
 - Data compression
 - Dynamic user-defined environment
 - Standard SW development methodology
 - Automated software documentation

- (M) Support the development of software that supports distributed execution across networks of massively-parallel systems

T&E needs to:

- (P) Encourage the development of models and simulations that are capable of real-time T&E applications

SUMMARY OF RESULTS: INDUSTRY DEVELOPMENTS

Industry Developments

- Improved Computer Hardware
- Graphics Output Capability

SUMMARY OF RESULTS:

INDUSTRY DEVELOPMENTS

INDUSTRY DEVELOPMENT

The T&E community should be cognizant of and ready to leverage activities being performed by private industry to develop new and improved products, particularly in the areas of:

- Computer hardware, where faster computers and/or more data storage capacity can make models and simulations run in less time
- Graphics output capability, where graphical and visual output can be used in models and simulations in real time during the running of the model

SUMMARY OF RESULTS: DEVELOPERS' HANDBOOK

Developers' Handbook

- **DMSO is to support use of M&S in T&E by the development of a M&S developers' handbook**

SUMMARY OF RESULTS:

DEVELOPERS' HANDBOOK

DEVELOPERS HANDBOOK

DMSO needs to:

(M) Support the development and distribution of a M&S developers' handbook, in coordination with the Defense Systems Management College (DSMC), which covers the following subjects:

- Portability
- Interoperability
- Credibility
- Usability
- Flexibility/reconfigurability
- Reusability
- Intermetting
- Security
- Linking
- Fidelity
- Variable fidelity/resolution/scale/scope
- VV&A
- Robust capability — multispectral, soft kill/hard kill
- Object oriented and open-systems architecture
- Real-time operations
- Man-in-the-loop
- Hardware-in-the-loop
- Distributability
- Accessibility
- Data interface standards, including data definitions, format, joint data/object dictionary, capability for on-line cases, capability for network stand-alone

SUMMARY OF RESULTS:

TOOLS & HANDBOOK

(CONCLUDED)

DEVELOPER TOOLS AND HANDBOOK (concluded)

DMSO needs to (concluded):

- (M)** Support the development and distribution of a M&S developers handbook (in coordination with DSMC) which covers the following subjects (concluded):
 - Data base capabilities, including:
 - standardized data definitions and formats
 - common data on-line dictionary
 - intelligent access procedures
 - validation audit trail
 - configuration management, maintenance, and distribution
 - multi-level security
 - accessibility
 - Writing development contracts so that the government has access to models, simulations, data bases and associated documentation (developed under contract) at reasonable cost
 - Promoting early involvement of T&E M&S managers, developers and users in the acquisition process to make T&E M&S requirements known for planning purposes

SECTION 3

EDUCATION, TRAINING, AND MILITARY OPERATIONS WORKSHOP SUMMARY

SECTION 3

EDUCATION, TRAINING, AND MILITARY OPERATIONS

WORKSHOP SUMMARY

BACKGROUND

- **Invitation to ETMO M&S Workshop from the chairmen, ETMO, and the DMSO**
- **ETMO M&S Workshop is the second of five workshops sponsored by DMSO**
- **Participants of ETMO M&S Workshop identified actions required to produce better modeling and simulation support to ETMO in the areas of**
 - **Joint training**
 - **Service interoperability**
 - **Military education**
 - **Military planning and rehearsal**

BACKGROUND

The Defense Modeling and Simulation Office (DMSO) sponsored the Education, Training, and Military Operations (ETMO) Modeling and Simulation (M&S) Workshop, reported in this document, as a forum to identify ETMO M&S requirements. The chairmen, ETMO, and DMSO invited the participants (listed in appendix B) to the ETMO M&S Requirements Workshop. (The appendices referred to in this section are contained in the individual workshop report.)

The DMSO sponsored the ETMO M&S Requirements Workshop as the second in a series of workshops in five functional areas (Education, Training, and Military Operations; Research and Development; Test and Evaluation; Production and Logistics; and Analysis). The output from this workshop will be used by the ETMO Functional Working Group (FWG) to guide the DMSO in promoting the effective and efficient use of M&S in the DOD.

Participants were asked to identify and prioritize requirements, deriving these from the Mission Essential Task Lists (METLs), the supporting tasks, and the M&S characteristics. Requirements addressed activities that should be funded in the near (zero to five years) and far term (beyond five years).

The workshop was conducted during the period 16 - 18 September 1992.

OBJECTIVE

- **The objective of the ETMO Workshop was to identify the M&S needs to support ETMO requirements**

OBJECTIVE

The objective of the ETMO Workshop was to identify the M&S needs to support ETMO requirements.

STRUCTURE

- **Four working groups**
 - **Mission Planning and Rehearsal**
 - **Joint Training**
 - **Service Interoperability**
 - **Military Education**
- **DMSO sponsored the ETMO Workshop review panel**

STRUCTURE

The ETMO Workshop was divided into four working groups: Joint Training, Service Interoperability, Military Education, and Mission Planning and Rehearsal. Mission Planning and Rehearsal refers to preparation for assigned joint missions, not training. Joint Training is in the context of training for potential assigned missions in support of the warfighting CINCs. Service Interoperability has to do with tasks concerning interaction of two or more services. The area of Military Education is concerned with the teaching process. Each working group identified M&S needs to support the working group's assigned area within ETMO.

After the workshop, DMSO sponsored a panel to review the workshop results. The review panel prepared a consolidated list of M&S needs for ETMO. The panel results are included in appendix A.

RECOMMENDED PROCESS FLOW

- **Determine Mission Essential Task Lists (METL)**
- **Determine supporting tasks**
- **Evaluate the training environment that supports the METL**
- **Determine M&S limitations**
- **Determine needed M&S characteristics**

RECOMMENDED PROCESS FLOW

All ETMO workshop working groups were briefed on a recommended approach to determining M&S needs.

The first step was to develop Mission Essential Task Lists (METL). Each group member was asked to independently list the mission essential tasks representative of the working group subject area. The working group chairman then asked each individual in turn for one mission essential task that had not previously been brought up.

In the next step, the group went over the METLs one at a time and listed the supporting tasks required for each METL.

The third step involved a review of the METLs and supporting tasks by the working group participants to determine if M&S can be used to effectively and efficiently assist training in support of the METL and whether M&S is currently being used. The group then described the general training environment needed to execute the METL and supporting tasks.

From the examination of the environmental description developed in the third step, the working group was then asked to identify any limitations to the use of M&S to the support the METL. Further, they looked at what future enhancements and/or additions would significantly benefit their use of M&S.

From the limitations, each working group prepared a list of characteristics/attributes of M&S requirements to effectively and efficiently support the needs of the ETMO community in the area of interest.

The results of the working groups are included in appendices C through F.

SUMMARY OF RESULTS

- **M&S integration**
 - **Live play and simulation interactions**
 - **Distributed, interoperable, open system architecture**
 - **Data evolve from real-world sources**
 - **Seamless interface with C4I**
- **Data base**
 - **Global**
 - **Common reusable data bases (e.g., civilian, logistics, threat, forces)**
 - **Use of real-world data (representative in some cases)**
 - **Automated development of data bases and scenarios**
 - **Archival, retrieval, configuration management**
 - **Traceability**

SUMMARY OF RESULTS

M&S INTEGRATION

Several perspectives were discussed regarding the integration of M&S. The integration of multiple constructive simulations to attain a joint capability is one perspective, the example being given of the Aggregated Level Simulation Protocol (ALSP). The integration of constructive with virtual simulations and live play is another perspective. A third perspective or level of integration is that of one or more of the three types (constructive, virtual, live) of simulations with the real-world C4I and weapons systems.

The workshop identified a common need for M&S to provide an environment that combines live play and simulations. All training is expected to benefit from the use of simulated environments, units, and unit commanders to represent a more realistic exercise. Ideally, personnel should not be able to differentiate between live play and M&S. M&S used for education, planning, analysis, training, and mission rehearsal should have a compatible look and feel. The same, or variants of the same, M&S and data should be used in each of the areas.

An open system architecture that allows distributed and interoperable M&S is required to support the wide diversity of military operations. M&S capabilities are expected to develop as separate modules such as command post simulations, weapon platform simulations, and environment simulations. An open M&S architecture will allow M&S capabilities to be combined as part of training exercises and to support military education.

The use of M&S to support ETMO, and, in particular, preparation for military operations requires the use of real world data. The use of M&S modules should be seamlessly integrated into the military organization's C4I structure, allowing the use of either exercise data or real-world data.

DATA BASE

M&S is often limited by data availability. Data bases are required that are geographically global in extent and cover a wide range of subjects. The data bases should use real-world data that is continually updated to reflect changing situations. However, security considerations may require the use of representative data for exercises and training.

The availability of data bases for M&S is often limited by the labor intensive requirements to generate and maintain data bases. Automated data base development, archiving, retrieval, and configuration management are required to address the data base bottleneck problems.

The sources, and history of assumptions, used to develop the data bases are as critical as the data itself. Therefore, M&S requires data that can be traced to the data source to allow verification of the applicability of the data.

SUMMARY OF RESULTS (CONTINUED)

- **Common tools**
 - **Selectable data capture, playback, and after action reporting**
 - **Graphics**
 - **Exercise management aids**
 - **Automated scenario generation**
 - **Embedded training feedback and evaluation tools**
 - **Automated data base development**

SUMMARY OF RESULTS (CONTINUED)

COMMON TOOLS

The ETMO Workshop working groups independently identified a common set of M&S tools, or utilities, required to support ETMO.

The M&S user needs the capability to "playback" user selected portions of the simulation and to capture critical data from the large amounts of data included in any model or simulation. Both automated after action reports of typically required data, and selectable data capture to identify the "why" of a particular result, are tools required by all users of M&S.

Graphical presentation of data is a standard requirement to allow quick assessment of relevant data.

Exercise management aids are needed to allow the exercise controller to track both live exercise players and simulated players. During the exercise, the exercise controller needs to monitor deviations in the exercise scenario, provide direction to units within the exercise, and have real-time evaluations on unit effectiveness. After the exercise, analysis tools are required to identify lessons learned from the exercise.

Automated scenario generation is needed to reduce the labor requirements to create a scenario and to increase the fidelity of scenarios while maintaining traceability back to data sources and assumptions.

All M&S will need to have embedded training feedback and evaluation tools. Each simulation within the open M&S architecture will have more internal data than data shared with the open architecture. Therefore, each model or simulation is expected to include training and evaluation tools to allow access to this data.

Finally, automated data base development is expected to be critical to allowing a wide range of M&S applications by eliminating much of the labor associated with the development and modification of data bases.

SUMMARY OF RESULTS (CONTINUED)

- **Environmental representation**
 - **Environmental data bases**
 - **Weather**
 - **Light conditions**
 - **Terrain**
 - **Sea**
 - **Electronic warfare (EW)**
 - **Thermal**
 - **Effects on sensors and systems**
 - **Development of standards and models**
 - **Support interoperable simulation**

SUMMARY OF RESULTS (CONTINUED)

ENVIRONMENTAL REPRESENTATION

The difficulty in providing good environmental representation in M&S was viewed as a combination of data base and model problems. Each model and simulation is impacted by a simulated, physical environment. The quality of the simulated environment needs to be improved through better data bases and better models of the interaction of simulations with the environment.

Geographically global data bases are needed to represent weather, light conditions, thermal conditions, terrain, and sea states. Electronic Warfare (EW) data bases are also required to create the expected threat (and friendly) electromagnetic environment.

The effects of local environment characteristics on sensors and systems need to be included in the models and simulations. Efficient development and utilization of environmental data bases and models requires that the data bases and models be developed as a standardized set.

With the establishment of data standards, interoperable simulation can use a centralized environment model such that all players encounter a consistent environment. For example, when there is rain (either real world or simulated play), all ground vehicles encounter mobility constraints, aircraft encounter clouds and rain, and sensors encounter appropriate weather effects. This vision of interoperable simulations needs to be supported to ensure efficient and realistic environmental representation.

SUMMARY OF RESULTS (CONTINUED)

- **New functionality**
 - **Social, economic, and political models**
 - **M&S should cover complete spectrum of military operations for all regions of the world**
 - **Mobilization and deployment process**
 - **Seamless integration of intelligence models**
 - **More than two-sided interactions**
 - **Predictive intelligence modeling capability**
- **Behavioral representation**
 - **Behavioral representation in threat specific models and non-adaptive behaviors for blue**
 - **Behavioral representation simulation of other staff, support, or agency functions**
 - **Selectable IFOR, SAFOR, and man-in-the-loop play**
 - **Variable input/output by friendly and opposing force component**

SUMMARY OF RESULTS (CONTINUED)

NEW FUNCTIONALITY

Which operations to be modeled and simulated was considered separately from data, data handling, and environment modeling. The general findings of the ETMO Workshop was that the M&S functionality needs to be extended to meet ETMO requirements. The needed functionality includes social, economic, and political models to support commanders in the evaluation of alternative command decisions. While combat simulations do exist, they should be expanded to cover the complete spectrum of military operations from intense combat to non-combat operations such as nation building and disaster relief. As part of the M&S of military operations, mobilization, deployment, and redeployment of military forces and assets should be added to the functionality of M&S.

In addition to widening the scope of military operations models, the complexity, or fidelity, of the models and simulations should also be improved. Intelligence models, and specifically predictive intelligence models, should be integrated into M&S. The M&S should not be limited to simple two-sided interactions. Coalition forces can have national goals and objectives that are only partially in accordance with United States goals, objectives, and strategies. Forces can change from hostile to neutral to allied during a campaign. These complexities need to be accounted for and represented in M&S.

BEHAVIORAL REPRESENTATION

Behavioral representation within M&S is required to extend the utility of M&S. Man-in-the-loop play is always limited by the labor requirements of including sufficient players to provide useful training and education. Behavioral representation allows the model or simulation to represent the behavior of players that are not available for the current exercise or training session.

Representation of specified threats (playing against the computer) includes threat representation that responds to Blue actions, within the doctrinal, training, and equipment constraints of the threat force. Representation of non-adaptive Blue force behavior would automate the execution of force or unit orders. Automated decision makers and staff support functions are required to extend the perceived scope of training and exercises both laterally to more units and vertically to represent support, staffs, and agencies not physically included.

M&S users should have selectable levels of behavioral representation. If the players are available, then man-in-the-loop should be used. If few players are available, then SAFOR, guided by a limited number of players, should be an available option. Or, the M&S user may simply choose IFOR due to the lack of available players.

In addition to selecting the level of representation, it should be possible to select the amount and detail of both input and output data by force component.

SUMMARY OF RESULTS (CONTINUED)

- **Security**
 - **Selectable transparency**
 - **Multi-level security**
- **Infrastructure**
 - **Easy access to information, data, and models**
 - **Simulation as a secondary specialty**
 - **Professional military education**
- **Attributes**
 - **Event-stepped**
 - **Multiple scenarios played**
 - **Monitorable**
 - **Interoperable**
 - **Re-baseline**
 - **Variable simulation speed selection**
 - **Etc.**

SUMMARY OF RESULTS (CONTINUED)

SECURITY

Security is a recurring issue with the integration of multiple players accessing multiple data bases that represent real-world situations and problems. Not only must data be transferred to realize M&S possibilities, but the security of that data must be maintained to avoid compromising operational and national security.

In order to achieve M&S applications to ETMO, an approved means must be established to control access to classified information. The users of M&S must have a level of classification selected and enforced for each user. For large integration of models and simulations, this implies multiple levels of security, not simply declaring the security level to the level of the lowest user.

INFRASTRUCTURE

A M&S infrastructure needs to be developed to ensure easy affordable access to information, data, and models. M&S should be established as a secondary military specialty and included in professional military education.

ATTRIBUTES

All working groups identified event-stepped models as the preferred mode to allow the greatest flexibility in model time versus user time. Three working groups repeated a desire to be able to speed up or slow down events through event-stepped models.

Two or more geographically separate military operations running concurrently are required to evaluate force employment options.

The M&S user should be able to monitor user selected data within the model or simulation. He should be able to interrupt the model or simulation during execution; and the user should be able to quickly and easily modify the model or simulation input data to establish a new baseline.

SUMMARY RESULTS (CONCLUDED)

- **Unique work group perspectives**
 - **M&S support of military planning and rehearsal**
 - **Real-world data into M&S**
 - **Mission analysis, planning, and rehearsal**
 - **Inclusion of coalition forces**
 - **M&S support of joint training**
 - **Exercise data into M&S**
 - **Exercise control and evaluation**
 - **M&S support of service interoperability**
 - **M&S support of military education**
 - **Limited resources to support student use of M&S**
 - **Emphasis on decision process, not decision results**
 - **Extend range of M&S**
 - **Management of force structure**
 - **Acquisition**

SUMMARY OF RESULTS (CONTINUED)

UNIQUE PERSPECTIVES

Although there were many primary needs identified of a common nature among the working groups, there are also unique perspectives of each group's area regarding the use of models and simulations. Listed below are the important differences which were brought out.

- **Military planning and rehearsal**

M&S support to operations emphasizes the use of high quality real-world data. Mission planners and operators want to simulate the mission and evaluate mission alternatives with the most current and best-possible quality data. A second major concern for planning and rehearsal is to include coalition force actions according to expected doctrine of coalition forces.

- **Joint training**

Use of M&S to support and enhance exercises requires real-world data be selectively replaced with exercise data. Also in addition to evaluating simply how well a mission may go, the exercise controller needs to be able to use the netted M&S environment to monitor, control, and evaluate the exercise.

- **Service interoperability**

The use of M&S in support of training is essentially the same as that for joint exercises. Additional use of behavioral representation may or may not be used to represent other component operations.

- **Military education**

Military education is severely resource constrained by the nature of the education process. Military operations and training can command relatively large M&S resources, whereas education is time and support resource constrained. Students using M&S cannot expect to be supported with large education-dedicated M&S infrastructures. Instead, M&S that can be operated without support (e.g., that fit on a personal computer) are preferred.

SECTION 4

PRODUCTION AND LOGISTICS WORKSHOP SUMMARY

SECTION 4

**PRODUCTION AND LOGISTICS
WORKSHOP SUMMARY**

7

INTRODUCTION

The Defense Modeling and Simulation Office (DMSO) sponsored the Production and Logistics (P&L) Modeling and Simulation (M&S) Workshop, reported in this document, as a forum to identify P&L M&S requirements.

The vision for modeling and simulation (M&S) support to P&L includes capabilities that can be achieved in the next ten years to make engineering and manufacturing processes significantly more versatile and cost effective. The vision encompasses an evolution of continuous test and validation of engineering technologies with the support of M&S. In the future, both development and testing will consist of significantly more simulation and significantly less hardware and/or field testing. Virtual reality will be a reality.

It is foreseen that the results of this workshop will be useful in the development of a rationalized M&S development plan that will quickly and cost-effectively bring about the "vision" of M&S support to P&L.

BACKGROUND

- **Invitation to the P&L M&S Workshop from the chairman, Production and Logistics FWG and the DMSO**
- **The P&L M&S Workshop is the third of five workshops sponsored by DMSO**
- **Participants of the P&L M&S Workshop identified actions required to produce better M&S support to P&L**
 - **Production**
 - **Logistics**

BACKGROUND

The chairman, Production and Logistics FWG, and the DMSO invited the participants (see appendix A) to the P&L M&S Requirements Workshop through designated service and agency points of contact. (The participants are listed in appendix C.) (The appendices referred to in this section are contained in the individual workshop report.)

The DMSO sponsored the P&L M&S Requirements Workshop as one in a series of workshops in five functional areas (Test and Evaluation; Education, Training, and Military Operations; Production and Logistics; Research and Development; and Analysis). The output from this workshop will be used by the P&L FWG to guide the DMSO in promoting the effective and efficient use of M&S in the DOD.

Participants were asked to identify and prioritize policy, management, and technical requirements. Requirements addressed activities that should be funded now and in the future.

The workshop was conducted at The MITRE Corporation facilities in McLean, VA, during the period 16 - 18 November 1992.

WORKSHOP OBJECTIVES

- **The primary objective of this workshop was to identify the most critical and common M&S needs of the P&L community**
- **An additional objective was to sensitize the P&L community to the Defense Modeling and Simulation Initiative (DMSI)**

WORKSHOP OBJECTIVES

The objectives of the workshop were to identify the most critical and common M&S needs of the P&L community and to sensitize the community to the Defense Modeling and Simulation Initiative (DMSI).

WORKING GROUPS

- **Day 1, Session 1: Service and agency briefings**
 - **Army**
 - **Navy**
 - **Air Force**
 - **Marine Corps**
 - **DOD agencies (Defense Logistics and Defense Mapping)**
- **Day 2, Session 2 : Functional area working groups**
 - **Production**
 - **Logistics**
- **Day 3, Session 3: Briefouts and discussion**
 - **Production**
 - **Logistics**

WORKING GROUPS

Working groups were organized to represent service and agency views.

The purpose of session 1 was to provide initial briefings on DMSO and allow services and agencies to present their critical needs for M&S support. Paper copies of the viewgraphs used for presentation in this session are in appendices D through K.

In Session 2, the participants met in work groups to discuss P&L community concerns and development needs in light of the service and agency views presented in session 1. Workshops were conducted in a manner to reach consensus on needs and prioritization of those needs.

A presentation of the draft statements of M&S needs was made to the executive panel in session 3.

WORKSHOP PROCESS AND PRODUCTS

- **The Production Group used a hierarchical approach to reach the needs, first identifying six areas of concern (needs), and then listing the associated expectations and specific requirements for fulfilling the expectations associated with the needs**
- **The Logistics Group utilized smaller teams to develop needs in functional areas and categorized the needs into critical, high priority, and routine**
- **Both groups listed the statement of need, with a needs background and requirements for meeting the need**
- **Products of the groups will be presented by group**

WORKSHOP PROCESS AND PRODUCTS

The two groups used different approaches to reach the needs.

The Logistics Group utilized a team approach, with the smaller teams first looking at requirements in functional areas; the larger group then categorized the nine separate needs identified as to critical, high, or routine priority. The briefing slides used for the Logistics Group presentation to the Executive Panel in session 3 are in appendix M.

During the P&L M&S Workshop, the Logistics Group identified nine separate needs. Based on the urgency of need as determined by the working group, the participants grouped the needs into three categories: critical, high priority, and routine.

The Production Group utilized a hierarchical approach, beginning first with areas of concern and then identifying specific requirements associated with those needs. The briefing slides used for the Production Group presentation to the Executive Panel in session 3 are in appendix N.

A white paper on P&L Issues, written in preparation for the workshop, is presented in appendix L.

Observations from the Executive Panel briefing are presented in appendix O.

Definitions used in the workshop are included in appendix P.

The following discussion provides a statement of each need, background of the need, and an identification of some of the key requirements which are necessary to satisfy the need. The group products will be presented, with the Logistics Group first, followed by the Production Group.

LOGISTICS CRITICAL NEED 1

Higher Fidelity Representation of Logistics in Combat Models

- **Background/explanation**
 - **Lack of logistics considerations in combat models**
 - **Logistics actions effects not reflected in terms of combat effectiveness**
- **Requirements to satisfy need**
 - **Appropriate levels of detail and interfaces need to be established**
 - **Logistics models should identify realistic data requirements**
 - **Interplay should be realistic between combat and logistics models for planning and training purposes**

LOGISTICS CRITICAL NEED 1

Higher fidelity representation of logistics in combat models:

There is a need within the M&S community to have a higher fidelity representation of logistics in combat models.

Background/explanation of need:

Combat models, in general, do not adequately represent logistics considerations. Logistic actions, such as battle damage repair, field level maintenance, attrition and resupply, are not modeled such that the effects of these areas are reflected in terms of combat effectiveness.

Requirements to satisfy the need:

There are three requirements which must be addressed to satisfy this need. First, the appropriate levels of detail and interfaces need to be established which consider strategic, tactical, and operational objectives. Second, the logistics models should identify realistic data requirements which can interface with combat models with the same degree of data fidelity. Third, the interplay between the combat and logistics models should be realistic enough that this product can be used as both a planning and training tool.

LOGISTICS CRITICAL NEED 2

Credible Logistics Data Bases and Data Collection Capabilities

- **Background/explanation**
 - **Current logistics data bases contain ill-defined, outdated, non-standard formatted planning factors**
 - **Data bases are time consuming to prepare**
 - **Many data bases have not been validated or accredited for joint applications**
- **Requirements to satisfy need**
 - **User access to and interface with credible source data on real-time basis**
 - **Standardized data definitions**

LOGISTICS CRITICAL NEED 2

Credible logistics data bases and data collection capabilities:

There is a need within the M&S community to create credible logistics data bases and data collection capabilities.

Background/explanation of need:

Current logistics data bases most often contain logistics planning factors that are outdated, in non-standard formats, and are ill-defined. As a result, the data bases are time consuming to prepare, especially across services and agencies for joint applications. The vast majority of data bases that have been developed by the DOD have never been validated or accredited for joint applications in M&S.

Requirements to satisfy the need:

The most significant data base requirement is to develop an environment where a user (modeler) has access to and can interface with credible-source data on a real-time basis for model design, development, and execution. In some cases this would require off-the-shelf, ready-to-use data such as in performing logistics assessments for the CINCs OPLANs. Another pressing requirement is to standardize data definitions between the services and Defense agencies for specific data elements and ensure consistent levels of detail are applied when this data is collected.

LOGISTICS CRITICAL NEED 3

A Planning/Execution Tool to Support the CINCs in OPLAN Assessments

- **Background/explanation**
 - **MOEs (e.g., mobility lift, sustainment, maintenance, readiness) not adequately expressed**
 - **Comprehensive model does not exist to identify critical logistics shortfalls**
- **Requirements to satisfy need**
 - **Capability to quantitatively assess logistics capabilities/shortfalls**
 - **Family or series of models to clearly identify problems items or processes**

LOGISTICS CRITICAL NEED 3

A planning/execution tool to support the CINCs in their OPLAN assessments:

There is a need within the M&S community to provide a capability to support the CINCs in their OPLAN logistics assessments.

Background/explanation of need:

Historically the logistics community has not adequately expressed measures for mobility lift, sustainment, maintenance, material sourcing, or medical readiness. Additionally, a comprehensive model is not known to exist which assesses appropriate data inputs from the services and defense agencies to identify critical logistics shortfalls.

Requirements to satisfy the need:

To satisfy this need, a capability is needed to quantitatively assess the logistics capabilities/shortfalls in the deliberate and contingency/crisis planning arenas. This capability could be represented by a family or series of models, but must be at a level of detail to clearly identify problem items or processes to improve the CINCs logistics posture.

LOGISTICS HIGH PRIORITY NEED 1

An Analysis Tool to Study Effects of Force Sizing and Unit Realignment on Logistics Infrastructure

- **Background/explanation**
 - **Current force reductions greatest since post-Vietnam**
 - **Concurrent change in mix of active and reserve forces, unit locations and major command composition**
- **Requirements to satisfy need**
 - **Capability to evaluate impacts on logistics infrastructure of changes in requirements, concepts, stockage levels, etc.**

LOGISTICS HIGH PRIORITY NEED 1

An analysis tool to study the effects of force sizing and unit realignment on the logistics infrastructure:

There is a need within the M&S community to develop an analytic capability to evaluate the effects of force sizing and unit realignment on the logistics infrastructure.

Background/explanation of need:

Currently the DOD is in the midst of the greatest force reductions since the post-Vietnam era. This includes not only a reduction in total forces but also a change in the mix of units both active and reserve, the location of these units, and the composition of major commands, such as the composite wing concept in the Air Force.

Requirements to satisfy the need:

A capability is needed to evaluate the impacts on the logistics infrastructure to include: item requisitioning, maintenance support concepts, sparing levels in terms of war reserves, pre-positioning, mobility lift requirements, port facilities, installation services, and support personnel requirements.

LOGISTICS HIGH PRIORITY NEED 2

Acquisition Modeling

- **Background/Explanation**
 - **Logistics Support Analysis (LSA) and Level of Repair Analysis (LORA) frequently performed in isolation from the design process**
 - **Current tools do not provide means of evaluating alternative designs**

LOGISTICS HIGH PRIORITY NEED 2

Acquisition modeling:

There is a need within the M&S community for acquisition logistics models and simulations which can interface to the design process in near real time to optimize readiness and support considerations.

Background/explanation of need:

Logistics Support Analysis (LSA) and Level of Repair Analysis (LORA) are two analytic tools that are available to the acquisition logistician to evaluate various logistics alternatives that affect all aspects of support planning. These tools, however, are frequently performed in isolation apart from the design process and also do not offer the designer a conceptual way to evaluate alternative designs in terms of reliability, maintainability, combat effectiveness, and overall logistics support.

LOGISTICS HIGH PRIORITY NEED 2 (CONTINUED)

Acquisition Modeling (Continued)

- Requirements to satisfy need
 - Standardize data element definitions between LSA/LORA
 - Define additional data requirements
 - Integrate LSA/LORA processes
 - Develop interfaces to the system/equipment design process
 - Develop M&S tools to evaluate the R&M of alternative designs during the design process
 - Develop M&S tools to evaluate alternative maintenance and support concepts based on system design, including a man-in-the-loop capability
 - Develop the requisite interfaces to evaluate effects of readiness and support tradeoffs on combat effectiveness

LOGISTICS HIGH PRIORITY NEED 2 (CONTINUED)

Requirements to satisfy the need:

There are multiple facets to satisfying this need. Currently, there are a number of analytical tools and data bases which are available to the acquisition logistician for use in the weapon system design process. LSA and LORA are two examples. These tools generally are not applied in real time in conjunction with the weapon system design process. As such, a tradeoff analysis to optimize the readiness and support aspects of a weapon system or assess the effects of these changes on combat effectiveness is not possible. Identified below are some of the key requirements which would need to be addressed to satisfy this need:

- Standardize data element definitions between LSA/LORA
- Define additional data requirements
- Integrate LSA/LORA processes
- Develop interfaces to the system/equipment design process
- Develop M&S tools to evaluate the R&M of alternative designs during the design process
- Develop M&S tools to evaluate alternative maintenance and support concepts based on system design, including a man-in-the-loop capability
- Develop the requisite interfaces to evaluate effects of readiness and support trade-offs on combat effectiveness

LOGISTICS HIGH PRIORITY NEED 3

Interfaces between Live, Virtual, and Constructive Models

- **Background/explanation**
 - **Logistics models have been principally constructive models, designed to address macro-level cargo movement**
 - **Need to examine interfaces with combat models which are designed to operate in near-real-time settings**

LOGISTICS HIGH PRIORITY NEED 3

Interfaces between live, virtual, and constructive models:

There is a generic need within the M&S community to develop interfaces between live, virtual, and constructive models.

Background/explanation of need:

In general, combat models are developed to operate in a near-real-time setting to provide realistic representations of battlefield scenarios. Logistics models, however, have been principally constructive models designed to address macro-level cargo movement and, therefore, do not reflect the sensitivities of a synthetic battlefield. As such, there is a need to examine the interfaces between these disparate approaches to modeling to ensure that a more realistic picture of the logistics posture can be modeled as part of the synthetic battlefield.

LOGISTICS HIGH PRIORITY NEED 3 (CONTINUED)

Interfaces between Live, Virtual, and Constructive Models (Continued)

- **Requirements to satisfy need**
 - **Review and assess current M&S standards and protocols**
 - **Identify any unique standards and protocols which may be necessary to interface logistics models with combat models and simulations (e.g., time compression)**
 - **Review M&S data requirements to ensure that realistic data can be captured to provide a picture of the logistics posture on the battlefield**
 - **Provide the capability to extract and infuse data between combat and logistics models**
 - **Actively participate in groups established to develop standards to ensure that logistics M&S needs are addressed in the design of those standards**

LOGISTICS HIGH PRIORITY NEED 3 (CONTINUED)

Requirements to satisfy the need:

The requirements necessary to satisfy this need have broader application than just the interfaces between logistics and combat models. In reality, this need is a subset of a broader requirement to define a core set of standards and interfaces that are suitable across DOD M&S applications. The following requirements are key to satisfying this need:

- Review and assess current M&S standards and protocols
- Identify any unique standards and protocols which may be necessary to interface logistics models with combat models and simulations (e.g., time compression)
- Review M&S data requirements to ensure that realistic data can be captured to provide a picture of the logistics posture on the battlefield
- Provide the capability to extract and infuse data between combat and logistics models
- Actively participate in groups established to develop standards to ensure that logistics M&S needs are addressed in the design of those standards

LOGISTICS HIGH PRIORITY NEED 4

Tools to Support Logistics Considerations in the PPBS Process

- **Background/explanation**
 - **Linking funding reductions to operational readiness is critical**
 - **Sufficient funding for secondary items is important for better demand forecasting**
 - **Munition requirements coordination is essential to budget allocation and execution**
- **Requirements to satisfy need**
 - **Better models to reflect impact of budget decisions**
 - **Models are needed to address different types of weapons systems, personnel issues, and secondary items**

LOGISTICS HIGH PRIORITY NEED 4

Tools to support the logistics considerations in the PPBS process:

There is a need within the P&L M&S community to develop the requisite tools to support logistics considerations in the Planning, Programming, Budgeting System (PPBS) process.

Background/explanation of need:

Linking reductions in funding for logistics budget line items to the impact on operational readiness for weapon systems is critical to showing the impact on force readiness. Especially important is ensuring sufficient funding for secondary items based on better demand forecasting techniques. Finally, coordination of munition requirements by the services and allies is essential to budget allocation and execution.

Requirements to satisfy the need:

Better analytic models are needed to accurately reflect the impact of budget decisions as related to funding for logistics line items. These models are needed to address different types of weapon systems, personnel issues, and secondary items.

LOGISTICS ROUTINE NEED 1

The Capability to Quantify Implications of Alternative Materiel Management Policies

- **Background/explanation**
 - **No current capability to assess impact of inventory management decisions/policies**
 - **Algorithm, criteria, and policy decisions need to be evaluated**
 - **Math modeling underway between services and DLA**
- **Requirements to satisfy need**
 - **Simulation model needed to evaluate inventory management model key design and development decisions**

LOGISTICS ROUTINE NEED 1

The capability to quantify the implications of alternative materiel management policies:

There is a need within the P&L M&S community to develop the capability to quantify the implications of alternative materiel management policies.

Background/explanation of need:

The DOD does not currently have the capability to assess the impact of inventory management decisions/policies on the performance of the system to the customer. As the new DOD inventory management system evolves for both repairables and consumable type items several design decisions concerning computational algorithms, stockage criteria, and stockage policy will need to be evaluated. Currently a "math-modeling" between the services and the Defense Logistics Agency (DLA) is underway. This group is reviewing for adoption those portions of existing models which could be integrated into a "best of breed" version for use by the community.

Requirements to satisfy the need:

A simulation type model is needed to evaluate *a priori* key decisions relating to the design and development of the new DOD inventory management model. This model could also be utilized by the mathematics modeling group to trade off competing algorithms in terms of their impact on the material management performance.

LOGISTICS ROUTINE NEED 2

An Analysis Capability to Evaluate NDI/COTS Equipment Performance Prior to Purchase

- **Background/explanation**
 - **NDI/COTS equipments frequently bypass normal acquisition process evaluation and testing**
 - **Tradeoff analysis is needed of NDI and COTS prior to testing and procurement**
- **Requirements to satisfy need**
 - **Identify the key readiness and support parameters used to evaluate those equipments which go through the DOD acquisitions process**
 - **Review the development procedures and technical data requirements for commercially developed products**
 - **Identify a family of readiness and support parameters necessary to evaluate NDI/COTS performance**
 - **Develop an approach to evaluate NDI/COTS equipment which considers variability between commercial and military requirements in terms of performance**
 - **Verify the approach through application of specific test cases**
 - **Implement the approach into the DOD acquisition process**

LOGISTICS ROUTINE NEED 2

An analysis capability to evaluate NDI/COTS equipment performance prior to purchase:

There is a need within the acquisition community to evaluate Non-Developmental Items/Commercial-off-the-Shelf (NDI/COTS) equipment performance against military specification equipment performance prior to purchase.

Background/explanation of need:

NDI and COTS equipments frequently do not go through the normal acquisition process. Therefore, mil-spec performance requirements for those equipments may not be evaluated through normal testing procedures or, for that matter, may not even exist. With shrinking defense budgets and a trend toward the use of commercial products to satisfy military requirements, there is a need for a capability to perform tradeoff analysis of commercial and NDI equipment performance prior to testing and procurement of these equipments for military use. Specifically, the analysis should be able to address acquisition logistics considerations such as reliability, availability, and maintainability (RAM) and overall logistics support constraints.

Requirements to satisfy the need:

- Identify the key readiness and support parameters used to evaluate those equipments which go through the DOD acquisitions process
- Review the development procedures and technical data requirements for commercially developed products
- Identify a family of readiness and support parameters necessary to evaluate NDI/COTS performance
- Develop an approach to evaluate NDI/COTS equipment which considers variability between commercial and military requirements in terms of performance
- Verify the approach through application of specific test cases
- Implement the approach into the DOD acquisition process

PRODUCTION NEED 1

Production/Manufacturing Tools for Integrated Product and Process Development

- **Background/Explanation**
 - **FWG late in taking advantage of M&S opportunities**
 - **Objectives need to be developed to communicate with synthetic battlefield**
 - **Baseline existing models/simulations**
 - **Develop new tools to support the IPPD process and factory environment**
 - **Develop necessary interfaces**

PRODUCTION NEED 1

Production/manufacturing tools for Integrated Product and Process Development:

There is a need to develop a variety of production/manufacturing tools and models that will support Integrated Product and Process Development (IPPD) and that will interface with the synthetic battlefield through an electronic media.

Background/explanation of need:

The P&L M&S FWG was late in initiating work to take advantage of the opportunities offered by models and simulations. Three main objectives are required to be fulfilled in order to communicate, qualitatively and quantitatively, with the synthetic battlefield through an electronic media. First is to baseline existing models/simulations and to ascertain their parameters (i.e., ability to communicate with each other and their utility). Second, develop new tools to support the IPPD process and the factory environment. Lastly, develop the necessary interfaces so that information from the synthetic battle can be used in the design and manufacturing environments for trade studies.

If these needs are not met, transition from R&D will be accomplished without the advantage that is offered by synthetic battlefield simulations. Trade studies will continue to be ad hoc, and cost, schedule, and performance parameters will not be optimized by an analytical military need methodology, but through best estimates that have resulted in cost overruns, poor performance, and extended schedules.

PRODUCTION NEED 1 (CONCLUDED)

Production/Manufacturing Tools for Integrated Product and Process Development (Concluded)

- Requirements to satisfy need
 - Capability to interface IPPD process model with the synthetic battlefield for improved design definitions
 - A requirement to establish a baseline for existing models/simulations for manufacturing and logistics to determine existing utility
 - Requirement to model manufacturing process and material parameter tolerances on system performance to aid in establishing designs that are robust with respect to production variability
 - Requirement to model factory floor operations for improved efficiencies
 - Through modeling techniques, convert product designs into factory floor operations and machine instructions
 - Requirement to interface manufacturing and logistics models with simulations (transportation, distribution, and supply) for improved problem solving

PRODUCTION NEED 1 (CONCLUDED)

Requirements to satisfy the need:

- Capability to interface IPPD process model with the synthetic battlefield for improved design definitions
- A requirement to establish a baseline for existing models/simulations for manufacturing and logistics to determine existing utility
- Requirement to model manufacturing process and material parameter tolerances on system performance to aid in establishing designs that are robust with respect to production variability
- Requirement to model factory floor operations for improved efficiencies
- Through modeling techniques, convert product designs into factory floor operations and machine instructions
- Requirement to interface manufacturing and logistics models with simulations (transportation, distribution, and supply) for improved problem solving

PRODUCTION NEED 2

Technical Processes and Data Models: Production Control and Shop Floor Control Models

- **Background/explanation**
 - **Many scheduling techniques are neither real-time nor accurate**
 - **IDEF0 and IDEF1 approaches are not sufficient for future needs**
- **Requirements to satisfy need**
 - **A flexible, real-time production schedule and shop floor modeling capability**
 - **New enterprise methodologies**
 - **Virtual reality techniques in manufacturing process design**
 - **Valid and integrated models for CAD, CAM, CALS, and CAE**

PRODUCTION NEED 2

Technical processes and data models: production control and shop floor control models:

A need exists for flexible production control schedule and shop floor control systems.

Background/explanation of need:

With respect to a flexible, real-time production schedule and shop floor modeling capability, currently there are many scheduling techniques but they are not real-time, nor are they accurate. Bottlenecks in production still result. With respect to new enterprise methodologies, current approaches consist of IDEF0 and IDEF1, but these are not sufficient for anticipated future needs. With respect to virtual reality techniques in manufacturing process design, this emerging technology is being used in commercial enterprise, e.g., architecture and interior decorating, but is not used currently in the design of manufacturing facilities or processes. Current efforts that apply to the requirement to validate and integrate models are the PDES development effort and the Navy Rapid Acquisition of Manufactured Parts (RAMP). The expectation for this element is the development of a joint set of achievable requirements for manufacturing model development and a set of integrated models and tools for technology developers. It is feasible to meet expectation within five years for certain of the above requirements and in excess of five years for others. The impact of not meeting this requirement is unnecessary iteration of manufacturing process configurations, continued manufacturing inefficiency, disruption, stoppage, inefficient allocation and use of resources, and increase in unit cost.

Requirements to satisfy the need:

For flexible production control schedule and shop floor control systems, there is a requirement to develop a flexible, real-time production schedule and shop floor modeling capability.

New enterprise methodologies that include flexible, computer integrated manufacturing, models of specific manufacturing processes, and models of factory operations are required.

To meet the virtual reality need, there is a requirement to develop and use virtual reality techniques in manufacturing process design.

There is a requirement to validate and integrate models for CAD, CAM, CALS, and CAE by means of an advanced technology demonstration for Thrust 7 (IPPD demonstration).

PRODUCTION NEED 3

Models and Simulation Support of DOD Remanufacturing and Repair

- **Background/explanation**
 - **No widely accepted capability to reverse engineer parts or systems**
 - **Technical data either unavailable or insufficient**
 - **Technical and policy implementation needed for development of engineering models and requirements**
- **Requirements to satisfy need**
 - **Models and simulations to support reverse engineering**

PRODUCTION NEED 3

Models and simulation support of DOD remanufacturing and repair:

There is a need for models and simulations to support the reverse engineering of parts for remanufacturing.

Background/explanation of need:

Currently, some automated methods exist for the reverse engineering of electronic parts, but there is no widely accepted, automated capability to reverse-engineer mechanical parts or systems. Technical data frequently is either unavailable or insufficient. There is an expectation that a set of reverse engineering model requirements and the models themselves can be developed within five years. Both technical and policy implementation will be required to make achievement of this requirement effective. The impact of not meeting this requirement will be the unavailability of replacement parts and the consequent decrement in DOD system readiness.

Requirements to satisfy the need:

There is a requirement to develop models and simulations that will support the reverse engineering of parts for manufacturing.

PRODUCTION NEED 4

Coordination with National and International M&S Standardization Efforts

- **Background/explanation**
 - **Emerging ISO and CALS efforts**
 - **Many current models developed without standards**
- **Requirements to satisfy need**
 - **Need to develop and use models that conform to standards**
 - **Need to participate in national and international standardization efforts**
- **Further maturation required of models and transfer mechanisms**

PRODUCTION NEED 4

Coordination with national and international M&S standardization efforts:

There is a need to develop and use models that conform to the standards established by national and international standardization efforts.

Background/explanation of need:

The capability for the integrated use of models and data on both a national and international scale is emerging with the ISO and CALS efforts. However, many existing models have been developed without standards, with the consequence that their integration with other models and data is limited. It is expected that meeting this requirement will result in the integration of P&L models on both a national and international scale, the international standardization of both interfaces between functional areas and interface requirements for models and simulations, and the identification of a nationally and internationally accepted set of functional requirements for P&L models and simulations. Current progress suggests that this requirement can be met within the next five years. The impact of not meeting this requirement will be a duplication of model development efforts and the inability to communicate among models, with the attendant loss in efficiency.

Requirements to satisfy the need:

To meet this need, there is a requirement to develop and use models that conform to the standards established by national and international standardization efforts. This requires participation in national and international standardization efforts. It also requires further maturation of CALS-type data models and mechanisms for the transfers of models and data to and from the commercial sector.

PRODUCTION NEED 5

Policy and Management Direction on Standardization of M&S

- **Background/explanation**
 - **Existing models are unable to inter-communicate**
 - **P&L needs requirements focus**
- **Requirements to satisfy need**
 - **Standards and conformance enforcement**
 - **Return on investment definition for P&L model development**

PRODUCTION NEED 5

Policy and management direction on standardization of M&S:

There is a need to sensitize the P&L community to the M&S program, enforce conformance to standards, and to define return on investment for P&L model development and science and technology funding priorities.

Background/explanation of need:

A number of manufacturing, management, cost and other models exist, but are unable to communicate with each other. In order to take full advantage of the model and simulation efforts it is necessary that all models/simulations be able to communicate with each other through an electronic media. Policy and standards are needed to ensure that new models and simulations are able to interface with each other, thus enabling connectivity between the synthetic battlefield and the virtual factory. In addition, P&L needs to obtain a focus for its requirements into the M&S (DMSO) decision process. Since P&L was late in forming a M&S FWG, the community is not completely aware of the advantages and opportunities that M&S can provide. By informing the P&L community of these advantages/opportunities, projects can be better defined that will provide the synergism necessary for IPPD and connectivity with battlefield simulations (i.e., definition for multi-service programs and a focus on hard requirements). Finally, a prioritizing of P&L manufacturing needs should be developed; and as part of this process a need exists to define the return on investment for P&L model development.

Presently, a draft policy document for M&S is in coordination; other needs are not being addressed. It is felt that these needs could be prioritized and completed in the near term (i.e., within the next five years). If these needs are not met, the impact will be a continued fragmentation and duplicity in development of models for the P&L community, no vehicle for supporting P&L requirements/needs in the science and technology (S&T) thrust areas, and a continuation of not getting a P&L focus into the M&S decision making process.

Requirements to satisfy the need:

- Information to the P&L community in regard to opportunities and advantages that M&S can provide
- Standards and capability to enforce conformance to the standards
- Definition of the return on investment for P&L model development in S&T funding priorities

PRODUCTION NEED 6

Industrial Base Reconstitution

- **Background/explanation**
 - **Defense industrial base is being down-sized**
 - **Commercial sector has replacement capability for some but not all defense requirements**
- **Requirements to satisfy need**
 - **Methodology to identify unique defense requirements**
 - **Models for industrial preparedness planning**

PRODUCTION NEED 6

Industrial base reconstitution:

There is a need for a capability to identify materials, labor skills, equipments or technologies that may be required for reconstitution and an ability to model the planning associated with reconstitution needs.

Background/explanation of need:

With the down-sizing of the defense industrial base a requirement exists to identify specific technologies, equipments, manufacturing skills and other assets that are unique to the national defense. While it is recognized that the commercial sector can replace some segments of the defense manufacturing base, through dual use technologies and manufacturing capabilities, it is also acknowledged that some defense requirements have no counterpart in that sector. Some dated data is available in industrial preparedness and planning documentation, but it is felt that much of the data is not suited for reconstitution modeling or simulation.

It is recognized that M&S for reconstitution is a long term objective. However, it is felt that unless a methodology is developed for the identification of our needs and requirements for defense specific applications and converted in an appropriate model, we may lose some critical manufacturing capabilities.

Requirements to satisfy the need:

A methodology needs to be developed to identify those segments of the industrial base that are unique to the National Defense. Those unique segments require identification and reconstitution data for these segments need to be developed for an appropriate model/simulation for industrial preparedness planning.

SECTION 5

RESEARCH AND DEVELOPMENT WORKSHOP SUMMARY

SECTION 5

RESEARCH AND DEVELOPMENT WORKSHOP SUMMARY

WORKSHOP OBJECTIVES

PRIMARY

- Define R&D community's needs for M&S support into the next century
 - Include consideration of supporting capabilities
 - Emphasis on common and joint needs
 - Major service unique needs captured also
 - Look toward the future

SECONDARY

- Amplify and provide background for major needs
- Inform community about what is going on in M&S
 - New technology and its creative application
 - New initiatives and on-going programs
- Form connections/links across and between workshop participants
 - Share information about how M&S is used

WORKSHOP OBJECTIVES

There were both primary and secondary objectives for the workshop for modeling and simulation (M&S) needs to support research and development (R&D).

The primary objective was to define the R&D community's needs for M&S into the next century. These needs included M&S support, e.g., data bases, computer hardware capabilities, etc. The workshop attendees were requested to emphasize needs common to the whole DOD, and needs that applied to joint service/agency applications of M&S. Major needs that are unique to a service were also to be identified and documented.

The workshop participants were asked to consider future needs that will arise from continued improvements in M&S supporting technologies, as well as needs that will evolve out of projected research developments.

The secondary objective was to improve the communications within the R&D community concerning the utilization of M&S. The workshop sought to establish and amplify the background for how M&S is used to support research in key DOD technologies. This workshop tried to both inform the R&D community and establish communications links within the R&D community on M&S applications. Workshop participants covered a wide range of technologies and programs. Discussions on the applications of M&S to new technologies, to new initiatives, and to on-going programs provided a chance for participants to share information on the uses of M&S.

VISION OF M&S SUPPORT TO R&D

- **Networked simulators, simulations, and constructive simulations are producing a revolution in the applications of M&S to military problems and issues**
- **M&S "prototyping" of new technologies could be used to identify the best technologies and technical applications for the DOD and support simulated prototyping to ensure the faster development of a better product**
- **Sharing of physical simulations can support both research into new technologies and the development of new applications for those technologies**
- **The development of linked simulators and simulations for R&D is an opportunity to transfer new capabilities from the DOD to the civilian community**

VISION OF M&S SUPPORT TO R&D

COL Ed Fitzsimmons of DMSO presented the DMSO vision of the use of networked simulators and simulations. Networking produced a revolution in the use of models, simulations, and simulators. This revolution brings the warrior back into military capabilities development. The networked use of simulations and simulators to evaluate tactics and doctrine has already been extended to prototyping new capabilities. The use of prototyping simulators will support product development that achieves second and third generation capabilities from the product's first generation.

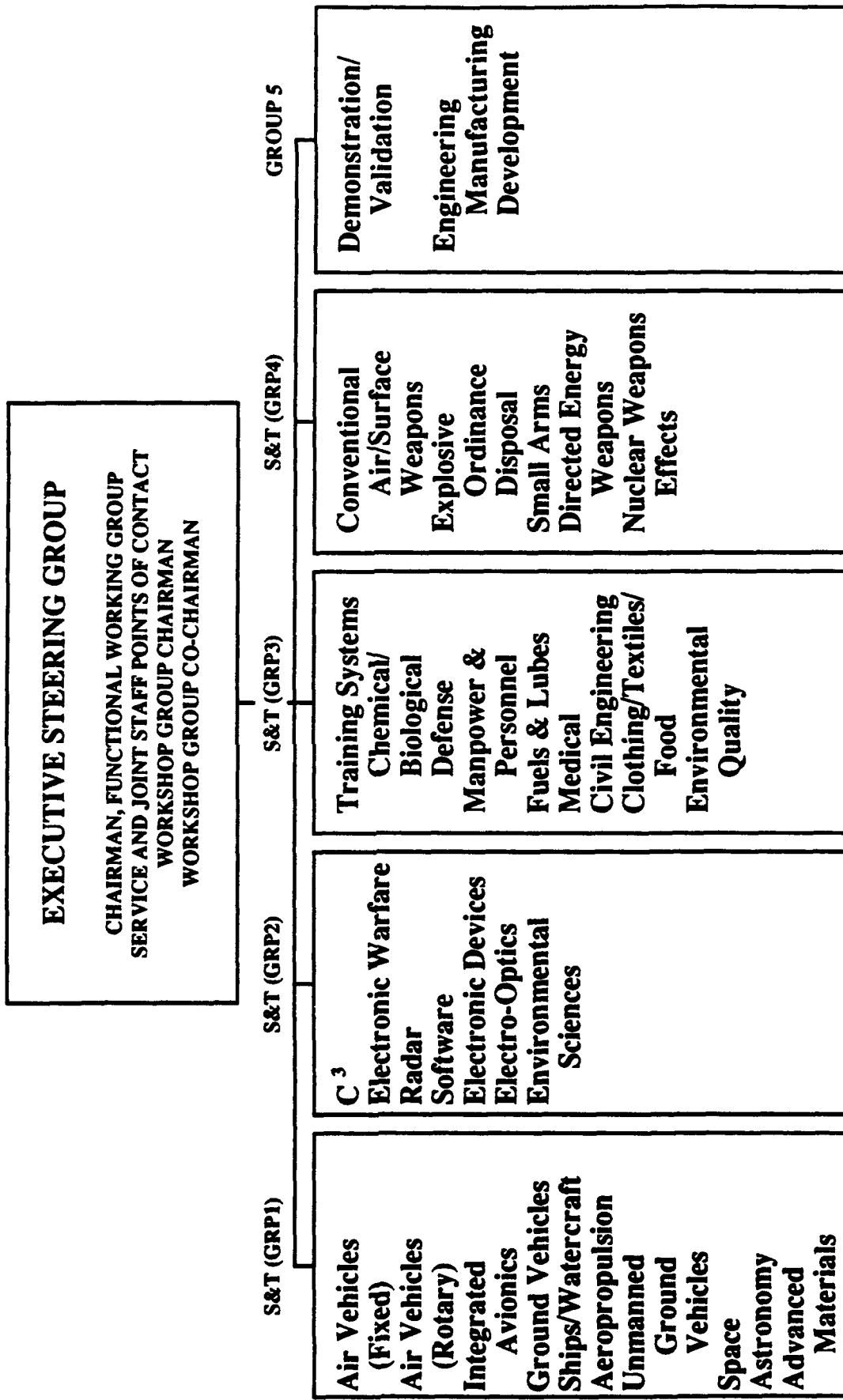
The workshop's vision of M&S is the use of M&S for early identification and selection of promising technologies. Physical representations of new technologies will be included in combat models and simulations to demonstrate the military impact of the new technologies. Networking of models and simulations will also be applied to the R&D process. Detailed physical models built with standardized data and data formats will be networked together to combine electronic, materials, aerodynamic, environmental, and other phenomena models to achieve higher levels of fidelity without recourse to ever larger individual physical models.

The use of simulations and simulators to evaluate tactics and doctrine has already been extended to prototyping new capabilities through modeling the new capabilities as modifications to simulations of current capabilities. The linking of subsystems to systems to units provides force effectiveness data to support system optimization. Prototyping simulators will support product development. Force effectiveness, suitability, and performance of each technology development will be determined from the modeling of multiple prototypes in simulated combat. M&S will provide both faster and more relevant evaluation of emerging technologies that will lead to better allocation of R&D resources.

The military paradigm of networked M&S will also be applied to the physical simulations of new physical processes. Individual R&D centers have their own models and simulations. Networking physical models will support the development of new technologies in the context of a broader range of detailed physical models. Physical models will be networked together to combine electronic, materials, aerodynamic, environmental, and other phenomena to achieve higher levels of system engineering, analysis, and evaluation capabilities without recourse to ever larger individual models.

The linking, or interoperability of models, simulations, and simulators by the DOD community is a DOD-unique technology. Applications of M&S capabilities to R&D for both technology and product development has applications to the civilian community. Therefore, as new ways are developed to use M&S to support R&D, the R&D community will identify promising tools and capability for civilian applications.

WORKING GROUP COMPOSITION



WORKING GROUP COMPOSITION

The R&D Workshop was divided into five working groups. Groups one through four encompassed the R&D research areas for S&T identified in the Tri-service Reliance in Science and Technology document prepared by the Joint Directors of Laboratories. The fifth group was drawn from R&D interests focused on engineering manufacturing development and demonstration/validation.

The intent was to form the workshop from a broad representative cross-section of the R&D community. Specialty areas were combined into working groups that had maximum cohesion. Almost all of the Tri-service Reliance in Science and Technology specialty areas were represented.

METHODOLOGY: WORK GROUP PRODUCTS

Session 1

- List of M&S roles now and in the future
- List of M&S types now and in the future
- Collection of M&S problems typically encountered

Session 2

- List of future M&S needs to support R&D
- Notation of expected critical issues in fulfilling

Session 3

- Final list of M&S needs compared to other WS
- Prioritized list of near-term (0-5 years) needs
- Prioritized list of long-term (>5 years) needs

METHODOLOGY: WORK GROUP PRODUCTS

Three days were allocated to develop near- and far-term prioritized lists of M&S needs for R&D.

The morning of the first day was devoted to orientation, DMSO, DARPA, S&T Thrust 6, and previous M&S needs workshops briefings. A detailed approach to identifying needs was presented to achieve the workshop objectives. Each group met separately for sessions 1 through 3.

The objective of session 1 was to identify roles and types of M&S used in each participant's organization and major problems typically encountered. Each member of each group described current and projected M&S role's in the member's organization. Each member described major problems in the use of M&S in the member's organization. The chairman of each group presented briefings summarizing each group's roles, types, uses, and problems in the use of M&S to the total workshop on the second day.

Session 2 defined all M&S support needed by the R&D community in the future. Each group considered M&S needs in three different phases. First, what is needed prior to executing a model or simulation? For example, what models are available? Second, what M&S needs arise during the execution of selected models or simulations? And finally, what needs arise after execution?

The objective of session 3 was to compare and prioritize the needs identified within each group. Each group was provided lists of M&S needs identified by the "analysis community", the T&E Workshop, the ETMO Workshop, and the P&L Workshop. The list of prioritized needs were to be grouped into near-term needs for zero to five years and long-term needs for five or more years.

On the afternoon of the third day, after session 3, each chairman briefed his working group's list of M&S needs for R&D to the entire workshop.

After the working group briefings, the chairman of the DMSO R&D functional group met in Executive Session with the chairmen and co-chairmen of each working group to achieve the consensus results reported below.

EXECUTIVE SESSION CONSENSUS: DIRECTION AND TOOLS FOR SUPPORT TO R&D

- Top down direction on how M&S is to be used for selecting alternative technologies, subsystems, and systems
- M&S infrastructure to support use of M&S by R&D community
 - "Library" of models, simulations, data, and scenarios
 - "Library" of standards for the use of M&S
 - "Library" of tools to use models, simulations, and data
 - R&D of new M&S capabilities and standards
- Specific models and simulations to enhance the use of M&S in R&D
- Top level managerial support of M&S support to R&D

EXECUTIVE SESSION CONSENSUS: DIRECTION AND TOOLS FOR SUPPORT TO R&D

During the executive session of the workshop chairmen and co-chairmen, the need for both "management" and "functional" M&S support to R&D was recognized. "Management support" is defined to include managerial functions that include selection of standards, allocation of areas of responsibility, implementation of policies and procedures, and communication of results/decisions. "Functional support" is defined to include providing models, simulations, data bases, research to develop standards, M&S development tools, and other software/hardware needed to provide M&S support to the R&D community with a focus on military user needs. In other words, M&S support needs to be both managed and substantive to engineer and evaluate advanced technology that meets user mission needs and operational requirements.

This slide summarizes a four point M&S "support structure" to enhance the use of M&S by the R&D community. Only two of the four "bullets" directly reference what is typically thought of as "modeling and simulation". The first "bullet" and the last "bullet" refer to "management" directed establishment of procedures and the management of M&S resources. The balance between the need for new M&S tools and models and the need for new ways for organizations to use and fund M&S was one of the most striking results of this workshop.

To meet the vision of using M&S to identify the preferred technology, subsystem, or system, the use of M&S to support the R&D community first needs direction on the appropriate methodologies to be used to make comparisons. Each R&D center wants to evaluate new technologies and systems on a "level playing field" so that the results at each center are directly comparable to the results from other centers. To achieve a "level playing field," uniform methodology, tools, and measures of success need to be developed at the direction of top levels of the DOD and published for use by the services and the R&D centers.

The management provided guidance must be supported by an "infrastructure" of universally available M&S tools. These tools, described in greater detail below will include the hardware and software typically required to run and operate models and simulations as well as enhanced access tools to obtain and use the models and simulations. A M&S "library" function will be critical to providing accessibility to the M&S tools. The infrastructure also will direct and/or conduct R&D to create new capabilities and establish new standards to use the new capabilities.

The workshop did not develop a list of needed specialized algorithms, models, or simulations. However, several new or enhanced capabilities were identified as needed to model and simulate the technologies being studies and developed by multiple members of the R&D community.

As resources are always limited, and M&S support crosses program lines, there should be a separate M&S management function that supports the M&S "infrastructure" for the DOD. This management function will refine the development of M&S capabilities across the DOD, sponsor or find dollars to support the "infrastructure," and fund the development of M&S technology.

PRIMARY M&S NEEDS IDENTIFIED BY WORKSHOP

- **Standards**
 - **Standard models and simulations that are VV&Aed**
 - **Standard data bases and scenarios**
 - **Standard protocols to establish interconnectivity**
- **Library (repository, distribution, and trainer) of M&S support to the R&D community**
 - **VV&Aed models, simulations, and data bases**
 - **Tools to modify models, simulations, and data bases**
 - **Tools to VV&A modified models, simulations, and data bases**
 - **Training on the use of M&S**
- **VV&A Capabilities**
 - **Standard procedures to accomplish VV&A**
 - **Automated tools to support the VV&A process**
- **Scenarios**

PRIMARY NEEDS IDENTIFIED BY WORKSHOP

This slide summarizes the top four priorities identified by both the separate work groups and the executive session of chairmen and co-chairmen.

The highest priority is the need for M&S standards. Validated and verified standard models and simulations are needed as a starting point. Approved data bases and scenarios are needed that will drive the models and simulations. Standard data definitions and formats are required to allow the transport of models and simulations between R&D centers. Interfaces and data protocols will be established to allow the networking of models and simulations. Open-system architectures will be defined for the system, subsystem, and physical/technology interface levels.

Many M&S capabilities exist, but can not be used to full potential due to access problems. A "library function" is needed that will include the capabilities to distribute VV&Aed models, simulations, and data bases; and to provide training. The access function of the library will include standardized documentation of all tools. Tutorials will be part of the documentation to provide any required training by the M&S practitioner.

Models, simulations, data bases, and tools from the library will be modified as part of the individual R&D program. When a M&S tool is modified, it will require VV&A to ensure the results are appropriate for comparison to results from other R&D programs and projects. VV&A support will include an established methodology and automated tools to implement that methodology.

Finally, "approved" scenarios will be used to represent the application of new technologies and systems to realistic operational situations. When a new technology or system points to the implementation of new tactics and doctrine, established scenarios will be supplemented and modified to represent the appropriate utilization of the new technology. Use of man-in-the-loop simulators will be an important aspect in the development of these new tactics and doctrine that lead to new scenarios for the utilization of proposed technologies and systems.

NEED FOR TOP DOWN M&S DIRECTION

- **Centralized guidance**
 - **Avoid duplication of effort**
 - **Develop standards for entire R&D community**
 - **Identify M&S technologies applicable across R&D community**
- **Standardized M&S methodologies for identifying promising technologies, subsystems, and systems**
 - **Standard scenarios, models, and simulations**
 - **Standardized methodologies to represent technologies, subsystems, and systems**
- **Standard M&S tools to be used within the methodology**
- **Standard measures supported by the tools**

NEED FOR TOP DOWN M&S DIRECTION

Top level direction is needed to ensure a broad use of M&S across R&D centers and across services. The R&D community has a long history of developing specialized M&S tools to support the conduct specific R&D programs. The multiple use of M&S tools, and particularly the rational selection or prioritization of R&D requires top down guidance and direction. Such guidance will focus the use of M&S and avoid the duplication of effort in the construction and VV&A of models and simulations. Standardized data formats; protocols to link models, simulations, and simulators; and standards development all require centralized direction. In addition to standards, the identification and development of M&S technologies to support the entire R&D community require a centralized organization that tracks the R&D community's evolving needs and the development of M&S technologies. Without direction, individual R&D centers cannot provide such direction.

The R&D community needs direction on the appropriate methodology, or methodologies, to be used to compare technologies, systems, and subsystems. The establishment of tools and procedures to compare technologies will let practitioners at all levels select the most promising alternative. The methodology to use M&S to make selections will include three elements. First, a standard baseline consisting of models and simulations accompanied by data bases that represent standard scenarios. Second, a standard methodology will be used to incorporate the new technology, system, or subsystem into the baseline. And third, standard measures of merit or effectiveness will be used to rank order the predicted payoff of each technology.

Standard M&S tools to implement the methodology will also be identified. M&S development environments will be used to modify sections of a model or simulation to represent the technical change. Automated validation and verification tools will be used to ensure the correct technical representation of a new technology. M&S tools will include standard environmental models. As no model or simulation is functional without data, a standard scenario and data base that represents the scenario is also required. Methodologies and procedures to modify the scenario to represent the tactics and doctrine that a new system can exploit will require tools that can draw on military expertise to develop proposed tactics and doctrine.

After a new system, subsystem, or technology is introduced to a scenario, the researcher still needs to know what are the critical issues associated with the scenario, and what are the measures of how well those issues are addressed. A standard set of measures, within the context of provided methodologies and tools will allow the R&D community to evaluate potential payoff of projects and programs. Since the methodologies and measures are standardized, then standardized data base extraction tools can be used to extract, organize, and present data.

M&S INFRASTRUCTURE SUPPORT TO THE R&D COMMUNITY

- **Standards**
 - **Develop**
 - **"Publish"**
 - **Maintain**
- **Standard models**
 - **Identify**
 - **V&V and provide accreditation procedure**
- **Data**
 - **Standard data definitions and formats**
 - **Standard model and simulator data interfaces**
- **Standard protocols to network models and simulations**
- **Standard VV&A tools**
- **Accessible support — "library" to models, data, and tools**

M&S INFRASTRUCTURE SUPPORT TO THE R&D COMMUNITY

M&S support to the R&D community needs centralized organization and direction. The development of standards for application across DOD R&D is too broad to be the responsibility of a single R&D center. The organization of projects to develop specific standards also requires centralized control. Once a standard is developed, it will require review to ensure community-wide applicability and utility. After review, the central organization for R&D support becomes a clearinghouse, or "publisher" of the new standard. Finally, as new technologies and requirements develop, the standards will be reviewed for adequacy and updated as required.

A family of models that satisfy the R&D community needs will be identified. Once identified, each model will be verified and validated for future use. The accreditation of a model or simulation for a particular use will be accomplished through a standard procedure that will be available to the R&D community.

Standard models can only be used if standardized data bases are available to drive the models. Modification of the M&S input data by members of the R&D community requires the use of standardized data formats, and definitions. The combination of multiple models and/or simulations will also require standardized model interfaces, or interface data processors, to allow the output from one model or simulation to be used as input to another model. The use of man-in-the-loop simulators will require the establishment of protocols to pass information across a network of models, simulations, and simulators.

Perhaps the most critical standards requirements are those associated with the validation and verification (V&V) of models and simulations. Accreditation of a particular simulation to the requirements of a particular program will be the responsibility of the program manager or of those who review the program. The difficulty of V&V of models and simulations for all cases limits the context of V&V. Accreditation tools are also needed. Accreditation tools can include a statistical analysis package to ensure the range of the input values that are consistent with test situations that the model or simulation is replicating. V&V tools can help accreditation by testing whether or not the "validated" part of the input data ranges includes those proposed for the particular program.

Standardizing, collecting, and V&Ving models and simulations will be wasted effort if the results are not available. M&S will be made available through a "library" of models, data, tools, and methodologies. The "library" need not be a centralized structure, instead it could be an electronic mail listing of products and points of contact. The "library" should include access tools to all the aspects of M&S. For M&S modifications, a M&S modification environment will support the development of variants of the "M&S library" products. In addition, the "library" will provide tutorial tools and facilities to train personnel on the use of any library item.

M&S APPLICATIONS FOR R&D

- **Data processing**
 - **Faster, cheaper, and more efficient**
 - **Tools to track modifications of VV&Aed data bases**
- **Simulation modifications tools that are easy to use**
 - **Analyst's "workbench" to modify models and simulations**
 - **Automated tools to VV&A modifications**
- **Tools to integrate laboratory and "field" test diagnostic data into simulations and simulators**
- **Multispectral scene generators to support R&D of new sensors**
 - **Standard, multispectral, scenario driven scene backgrounds**
 - **Standard, multispectral complex targets integrated into scene**
- **Other physical models applicable to multiple R&D projects**

M&S APPLICATIONS FOR R&D

Faster and cheaper data processing techniques are needed by the entire R&D community. Such tools include hardware to interface test diagnostic outputs directly into data bases. Automated techniques are needed to create and modify complex data objects and discreet data values in large data bases. With increased use of M&S, larger amounts of data will be generated, this data will require standardized data base manipulation packages or environments to analyze data and report the relevant results.

When a new technology, subsystem, or system is being researched and developed, existing models and simulations will be enhanced to represent the new technology, subsystem, or system. Input and output data will be reviewed and modified. A model and simulation "workbench" of tools will be needed to support data and model modification, verification, and validation. The workbench environment will include training to allow use by all R&D professionals, not just M&S experts.

In addition to tools that modify current M&S capabilities, automated tools will translate laboratory and field test data into M&S data bases. Also, tools will translate M&S output data back into test parameters of specific diagnostics.

One particular technology that has a wide R&D application will be multispectral scene generators to support the R&D of new sensors. These scene generators will include both multispectral standardized, or approved scenario, "backgrounds" and multispectral targets. The "complexity" of both the target and "background" will reflect the expected resolution capabilities of different sensors.

Other physical models will be developed based on the need by multiple R&D projects. The further development of Project Reliance allocation of areas of responsibility or other mechanisms will avoid duplication of efforts and ensure the efficient development of models at centers of modeling excellence.

MANAGEMENT OF M&S SUPPORT TO THE R&D COMMUNITY

- **Oversight management of M&S support to R&D**
- **Centralized advocate for funding M&S infrastructure support**
- **Centralized management of funding of R&D of M&S technology**
- **Centralized planning for future of M&S support to R&D**

MANAGEMENT OF M&S SUPPORT TO THE R&D COMMUNITY

The establishment of a "library", standards and other tools to support the use of M&S by R&D, and the development of new R&D oriented models and simulations will require oversight management. The day to day operation and maintenance of these capabilities will also require management.

Beyond setting up and operations of M&S support functions, the M&S support will be a centralized "advocate" of M&S support for R&D. The M&S "advocate" will coordinate and represent the M&S support community's funding requirements within the DOD funding process.

In the course of justifying the M&S infrastructure cost structure, the M&S support to R&D management will also function as a centralized management center for the development of new capabilities in M&S technologies.

In summary, to avoid wasteful duplication of M&S efforts and to achieve M&S capabilities not justified by individual R&D programs, the M&S infrastructure will take the responsibility for planning for the future of M&S support to R&D.

SECTION 6

ANALYSIS NEEDS STATEMENT

SECTION 6

ANALYSIS NEEDS STATEMENT

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1. Develop procedures and techniques that will enable a user to verify, validate, and accredit models and simulations:
 - a. Clearly the user will not be able to fully achieve all of the VV&A objectives for every model and simulation. However, a user must have the tools available to be satisfied that the M&S that is being used is credible. Good definitions of exactly what is meant by VV&A must be provided so that a user can determine which level in the process can be achieved.
 - b. Proposals should address the procedures and techniques to be developed that would allow a user to systematically check the model or simulation with criteria that would provide reasonable confidence that models or simulations can undergo VV&A.

Any effort must develop standards for defining VV&A that will be acceptable throughout the M&S community. The standards must address VV&A of M&S for various uses and various levels of fidelity. The proposals should also look at ways to use automation to facilitate the VV&A process. Proposals should be consistent with dollar amounts and use as a baseline the VV&A results of the Military Operations Research Society (SIMVAL) efforts and documented DOD VV&A guidelines (e.g., AR 5-11 "Army Model & Simulation Management Program").

2. Standardization of data bases:
 - a. Data bases must be standardized so that data elements can be used across M&S applications. Some of the areas where standardized data bases would be extremely useful are terrain modeling, environmental modeling, system performance characteristics, and cost modeling. In addition, it will be important to develop interfaces across data bases and models so that data from one model can be used in another model.
 - b. Proposals should address the development of a data base architecture that would standardize data descriptions and data elements and provide specific definitions to avoid ambiguity as data is used by more than one model. The proposal should include details on data base construction and procedures that can be published and accepted by all users. In addition, it would be desirable for a proposal to address how the multitude of current legacy data bases could be converted into data bases that could be used in multiple models and simulations and across services.

3. Development of tools to make M&S more responsive and usable:

- a. These issues are largely software related. They include such things as reusable code, software standardization, open architectures and interfaces, graphical user interfaces, object-oriented programming, parallel processing information retrieval systems, real-time graphics output, and statistical analysis capability, artificial intelligence, and on-line analysis of data bases. In addition, projects should be funded to improve model linkage and to help develop smaller, faster, and more powerful models.
- b. Proposals should address specific tools to make M&S more responsive and usable and provide recommendations on how to implement the items discussed in the above paragraph.

4. Analysis of M&S functionality gaps/needs:

- a. There are a number of areas that are difficult to model that are typically not addressed or are poorly addressed in most M&S efforts. Some of these areas are:

C3I

Human Factors

Standard environmental/terrain factors

Scenario impacts/effects

Electronic environment

There is also a requirement to better estimate resource requirements during early program phases of a weapon system acquisition and to estimate software life cycle costs.

- b. The proposals should provide techniques on how to better model each of these areas. Proposals should also provide some insight on the current shortcomings that prevent these areas from being satisfactorily modeled and what could be done in the future to address these shortcomings.