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A REVIEW OF STUDY PANEL RECOMMENDATIONS FOR DEFENSE MODELING AND SIMULATION

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This paper reviews the recommendations made by senior study panels, such as those of the Defense Science Board, the Army Science Board, and the General Accounting Office, concerning Defense modeling and simulation. A total of 179 recommendations were identified, made by 25 different study panels over a period of about 16 years. Overall they provide a foundation for the work of the Defense Modeling and Simulation Office (DMSO) which was established in 1991. In this review, each recommendation was categorized with regard to which DMSO General Objective, Functional (Application) Area, and Technical Objective it addresses. Each recommendation was also categorized with regard to what action (application, targeted research and development, technical improvement, modeling and simulation development, management improvement, and coordination) it advocates. Common themes found in the recommendations concern opportunities and needs for improved coordination, increased involvement and responsibility of higher management, more systematic and comprehensive planning, improved technology, improved technical quality, increased information sharing and feedback, broadened perspective, and new and extended opportunities for modeling and simulation, including increased application in system acquisition, test, and evaluation.

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ABSTRACT

This paper reviews the recommendations made by senior study panels, such as those of the Defense Science Board, the Army Science Board, and the General Accounting Office, concerning Defense modeling and simulation. A total of 179 recommendations were identified, made by 25 different study panels over a period of about 16 years. Overall they provide a foundation for the work of the Defense Modeling and Simulation Office (DMSO) which was established in 1991. In this review, each recommendation was categorized with regard to which DMSO General Objective, Functional (Application) Area, and Technical Objective it addresses. Each recommendation was also categorized with regard to what action (application, targeted research and development, technical improvement, modeling and simulation development, management improvement, and coordination) it advocates. Common themes found in the recommendations concern opportunities and needs for improved coordination, increased involvement and responsibility of higher management, more systematic and comprehensive planning, improved technology, improved technical quality, increased information sharing and feedback, broadened perspective, and new and extended opportunities for modeling and simulation, including increased application in system acquisition, test, and evaluation.

CONTENTS

TABLES

GLOSSARY

AAIP	Army Analysis Improvement Program
AC	Active Component (Active Forces)
AI	artificial intelligence
ALB	AirLand Battle
AMC	Army Material Command
	Army Models Committee
AMIP	Army Models Improvement Program
AMMO	Army Model Management Office
ARI	Army Research Institute
ASB	Army Science Board
ASD	Assistant Secretary of Defense
CAC	Combined Army Command
CBR	Chemical, Biological, Radiological (Warfare)
CENTCOM	Central Command
CGTU	Crew, Group, Team, Unit
CIC	Combat in Cities
CINC	Commander in Chief
CNO	Chief of Naval Operations
COEA	Cost and Operational Effectiveness Evaluation
AFHRL	Air Force Human Resources Laboratory
CSA	Chief of Staff Army
CSS	Combat Service Support

DA	Department of the Army
DAB	Defense Acquisition Board
DARPA	Defense Advanced Research Projects Agency
DCNO	Deputy, Chief of Naval Operations
DCSOPS	Deputy Chief of Staff of the Army for Operations
DCSPER	Deputy Chief of Staff of the Army for Personnel
DDR&E	Director of Defense Research and Engineering
DMSO	Defense Modeling and Simulation Office
DOT&E	Director of Operational Test and Evaluation
DSB	Defense Science Board
DSLOG	Deputy Chief of Staff of the Army for Logistics
DSM&P	Devices, Simulations, Methods, and Practices
DUSA(OR)	Deputy Under Secretary of the Army for Research Operations
EAC	Echelon Above Corps
ECCM	Electronic Counter-Countermeasures
ECM	Electronic Countermeasures
ET&MO	Education, Training, and Military Operations
EXCIMS	Executive Council for Models and Simulations
FFRDC	Federally Funded Research and Development Center
FM&P	Force Management and Personnel
FORCEM	Force Evaluation Model
FORGE	Force Evaluation Model Gaming Evaluator
GAO	General Accounting Office
HQDA	Headquarters, Department of the Army
IG	Inspector General
JCS	Joint Chiefs of Staff

JDL	Joint Directors of the (Defense) Laboratories
JESS	Joint Exercise Support System
JTLS	Joint Theater Level Simulation
LANL	Los Alamos National Laboratory
LSA	Logistics System Analysis
M&S	Modeling and Simulation
MACOMS	Major Commands (U.S. Army)
MAPP	Modern Aids to Planning Program
MOBA	Military Operations in Built-up Areas
MOBACS	Military Operations in Built-up Areas Combat Simulation
MOUT	Military Operations in Urban Terrain
MRA&L	Manpower Reserve Affairs and Logistics
MTM	McClintic Theater Model
NCO	Non-Commissioned Officer
NDI	Non-Developmental Item
NPRDC	Navy Personnel Research and Development Center
NTEC	Naval Training Equipment Center
OJCS	Organization of the Joint Chiefs of Staff
OPLANS	Operations Plans
OPTEMPO	Tempo of Operations
ORSA	Operations Research/Systems Analysis
OSD	Office of the Secretary of Defense
OT&E	Operational Test and Evaluation
PEO	Program Evaluation Office
R&D	Research and Development
RAM/ILS	Reliability and Maintainability/Integrated Logistics System

RC	Reserve Components
RECOM	Readiness Command
SCORES	Scenario Oriented Recurring Evaluation System
SCP	Support Concept Plan
SDC	System Development Concept
SHAPE	Supreme Headquarters Allied Powers, Europe
SIMNET	Simulated Network
SIMTECH	Simulation Technology
STC	SHAPE Technical Center
T&E	Test and Evaluation
TEMP	Test and Evaluation Master Plan
TES	Tactical Engagement Simulation
TRAC	TRADOC Analysis Command
TRADOC	Training and Doctrine Command
URBWAR	Urban Warfare (model)
USDRE	Under Secretary of Defense for Research and Engineering
VCNO	Vice Chief of Naval Operations
VCSA	Vice Chief of Staff Army
VCSAF	Vice Chief of Staff Air Force
VSR	Visual Stimulation Research
WPC	Warrior Preparation Center

SUMMARY

This paper reviews the recommendations for improving Defense modeling and simulation made by senior study panels, such as those of the Defense Science Board, the Army Science Board, and the General Accounting Office. These recommendations were made by 25 different study panels over a period of about 16 years. Most of these study panels were sponsored by the Office of the Secretary of Defense (OSD) or Army organizations.

A total of 179 recommendations were identified for this review. Each recommendation:

- Was made by a formally convened study panel assembled to address a specific matter of interest articulated in a charter or terms of reference.
- Discusses modeling or simulation explicitly or is included in a study explicitly convened to address Defense modeling and/or simulation issues.
- Is not classified.
- Is accessible through ordinary means (e.g., Defense Technical Information Center).

The paper does not discuss why each study panel made its recommendations, nor does it comment on whether anything was done to implement the recommendations. Nonetheless, the fact that many recommendations were made repeatedly suggests that more should be done to implement them.

The recommendations identified for this review provide a foundation for the work of the Defense Modeling and Simulation Office (DMSO), which was established in 1991. Each recommendation was classified according to the DMSO General Objective, Functional (Application) Area, and Technical Objective it addresses and according to which of six actions it recommends. The results of these classifications are tallied in Table S-1.

Common themes that run though the recommendations concern the opportunities and needs for: increased information sharing and feedback, increased involvement and responsibility of higher management, broadened perspective, more systematic and comprehensive planning, improved technology, improved technical quality, improved

coordination, and new and extended applications for modeling and simulation, especially in system acquisition, test, and evaluation.

Table S-1. Tallies from Four Classifications of the Modeling and Simulation Recommendations

	Recommendations	
	Number	Percent
General Objectives		
Management	90	50
Policy	14	8
Investment	75	42
Total	179	
Functional Areas		
Education, Training, and Military Operations	63	35
Research and Development	23	13
Test and Evaluation	24	13
Analysis	65	36
Production and Logistics	4	2
Total	179	
Technical Objectives		
Architectural Development	1	1
Methodology Development	123	69
Advanced Technologies	18	10
Information Sharing	37	21
Total	179	
Actions		
Application Area	29	16
Targeted Research and Development	34	19
Technical Improvement	39	22
Modeling and Simulation Development	12	7
Management Improvement	45	25
Coordination	20	11
Total	179	

The conclusions drawn from this review are the following:

- Interest in Defense modeling and simulation is widespread and persistent.
- There are substantial needs and opportunities for sharing information, capabilities, and resources within and among the Defense modeling and simulation communities.

- More attention should be paid to the verification, validation, and accreditation of Defense models and simulations.
- Some specific areas, such as the architectural issues of interoperability and specification of standards and the life-cycle support of Defense models and simulations themselves, deserve more attention and support.
- There are substantial needs and opportunities for improving the technologies underlying Defense modeling and simulation.
- There are many areas to which Defense modeling and simulation either should be applied anew or extended, especially those associated with system acquisition.
- More needs to be done to unite the modeling and simulator communities into an integrated, coordinated community prepared to address the problems of warfighting.
- Joint warfighting represents a significant area for increased use of modeling and simulation.
- There are substantial needs and opportunities for improving management and coordination of Defense modeling and simulation activities.
- Development of standards is needed to permit ready sharing of modeling and simulation data and resources.

A REVIEW OF STUDY PANEL RECOMMENDATIONS FOR DEFENSE MODELING AND SIMULATION

A. BACKGROUND

This paper reviews recommendations for improving Department of Defense (DoD) modeling and simulation made by senior study panels, such as those of the Defense Science Board (DSB), the Army Science Board (ASB), and the General Accounting Office (GAO). The draft DoD directive on modeling and simulation gives the following definitions for models and simulation:

- Model. A physical, mathematical, or otherwise logical representation of a real-world system, entity, phenomenon, or process.
- Simulation. A method for implementing a model over time. Also, a technique for testing, analysis, or training in which real-world systems are used, or where real-world and conceptual systems are reproduced by a model.

The definitions used by the study panels for this review were more frequently implicitly assumed than explicitly stated, but their recommendations were taken at face value. If a study panel or one of its recommendations stated that it concerned modeling and/or simulation, we assumed that it did.

The study panels identified for this review were chartered to address specific matters of interest to the Defense decision makers who sponsored them. Over the last 16 years, these panels have frequently noted both the opportunities and requirements for Defense modeling and simulation in their recommendations for action. These recommendations provide a foundation for the work of the Defense Modeling and Simulation Office (DMSO), which was established in 1991, and the policies and procedures it pursues.

DMSO was established in response to steady and significant increases in the technological opportunity provided by improvements in computation, communication, and graphics for modeling and simulation and in requirements for more efficient (1) research, development, acquisition, assessment, and deployment of modern weapons, (2) responses

to continuing and rapid changes in the threat environment, and (3) responses to environmental and budgetary constraints.

DMSO supports and promotes applications of modeling and simulation in the Department of Defense to joint education and training, research and development, test and evaluation, and analysis by:

- Establishing OSD cognizance and facilitating coordination among DoD modeling and simulation activities.
- Promoting the use of interoperability standards and protocols where appropriate.
- Stimulating a high return on investments in joint use modeling and simulation.

Based on this charter, DMSO has adopted the following objectives:

- Promulgate standards to promote interoperability of the components of the modeling and simulation environment.
- Support development of databases, tools, and methodologies for community-wide use.
- Promote development of a communications infrastructure to support integration of joint modeling and simulation activities.
- Facilitate community-wide coordination and information sharing (e.g., cataloging of existing models and simulations).

B. PURPOSE

This paper identifies study panel recommendations that have addressed Defense modeling and simulation and summarizes them in ways meant to assist DMSO and the Defense modeling and simulation community. The paper does not discuss why each study panel made its recommendations, nor does it comment on whether anything was done to implement them. The fact that many recommendations have been made repeatedly suggests that more should be done to implement them, but implementation is not the issue addressed here. The task was to identify, list, and summarize the recommendations.

C. METHOD

The data for this review were recommendations made by boards convened to advise the DoD. Recommendations come to Defense decision makers from many different sources. The criteria for including a recommendation in this review were the following:

1. It should be included as a specific recommendation in a formally convened study panel (such as a Defense Science Board or Army Science Board study group) assembled for a specified period of time to address a specific matter of interest articulated in a charter or in terms of reference by a sponsor concerned with the operations of the DoD. Recommendations from authoritative groups such as the Military Operations Research Society or one of the Service laboratories, without such a specific charter, were not included. Recommendations from the United States General Accounting Office were included.

2. It should discuss modeling and/or simulation explicitly or be included as a recommendation in a study explicitly convened to address Defense modeling and/or simulation. Additional recommendations may be relevant to Defense modeling and simulation but were not included in order to reduce ambiguity about which recommendations were and were not candidates for inclusion in this review.

3. It should not be classified. Few recommendations that would otherwise have been included in this review were classified, and their inclusion would not substantially change the nature of results reported here. Their exclusion permits public release and distribution of this document.

4. It should be accessible through ordinary means. The recommendations that were included in this review and the study panel reports from which they were drawn should be readily accessible to members of the Defense modeling and simulation community.

D. RESULTS

A total of 179 recommendations from the reports of 25 senior study panels were included in this review. Their years of appearance and study sponsors are shown in Table 1. As the table suggests, a variety of sponsors over the last 16 years have requested studies and received recommendations concerning Defense modeling and simulation. The table also suggests that sponsor interest in modeling and simulation may be increasing since eight of the 25 studies, with 113 of the 179 recommendations, were sponsored in the last 4 years. Most of the sponsors are OSD or Army organizations.

Table 2 shows the organizations that acted as sources for organizing the study panels and delivering their recommendations to sponsors. In 8 of the 25 studies the study organizer and its sponsor were the same. The 17 remaining studies were organized either by the Defense Science Board or Army Science Board, and 138 of the 179

Table 1. Numbers of Recommendations by Year and Study Sponsor

Sponsor[a]	Year																Number	
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Recommen-dations	Studies Requested
USD(A)														9			9	1
DDR&E	3						5			1	3		6				18	8
ASD(FMP) &DDR&E															7		7	1
DoDIG														12			12	1
ASA(RDA)				13	4	7		1						5			30	5
DUSA(OR)																12	12	1
DCSOPS										7			59				66	2
DCSPER &DCSLOG										4							4	1
JDL								4									4	1
GAO					5			7				2	3				17	4
Total	3	0	0	13	9	7	5	12	0	12	3	2	68	26	7	12	179	25

[a] USD(A) Under Secretary of Defense for Acquisition
DDR&E Director of Defense Research and Engineering
ASD(FMP) Assistant Secretary of Defense for Force Management and Personnel
DoDIG Department of Defense Inspector General
ASA(RDA) Assistant Secretary of the Army for Research, Development, and Acquisition
DUSA(OR) Deputy Under Secretary of the Army for Operations Research
DCSOPS Deputy Chief of Staff of the Army for Operations
DCSPER Deputy Chief of Staff of the Army for Personnel
DCSLOG Deputy Chief of Staff of the Army for Logistics
JDL Joint Directors of (Defense) Laboratories
GAO General Accounting Office

Table 2. Numbers of Recommendations by Year and Source

Sponsor[a]	Year																Number	
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Recommen-dations	Studies Requested
DSB	3						4			1	3		6	9			26	8
DDR&E							1										1	1
ASD(FMP) &DDR&E															7		7	1
ASB				13	4	7		1		11			59	5		12	112	9
DODIG														12			12	1
JDL								4									4	1
GAO					5			7				2	3				17	4
Total	3	0	0	13	9	7	5	12	0	12	3	2	68	26	7	12	179	25

[a] DSB Defense Science Board
DDR&E Director of Defense Research and Engineering
ASD(FMP) Assistant Secretary of Defense for Force Maintenance and Personnel
ASB Army Science Board
DoDIG Department of Defense Inspector General
JDL Joint Directors of (Defense) Laboratories
GAO General Accounting Office

recommendations came from studies organized by these two organizations. Almost a third of the recommendations came from a single 1988 Army Science Board study on the use of Army combat models for analysis and training of joint and combined operations.

All the recommendations are listed in reverse chronological order in Appendix A and are presented nearly verbatim from their sources. Many of the study panel reports that provide these recommendations are accessible through the Defense Technical Information Center (DTIC), and a DTIC accession number is given wherever possible.

The current organization of DMSO was used to categorize the recommendations. Currently DMSO is organized into three General Objectives, five Functional (or Application) Areas, and four Focus (or Technical Objective) Areas. All 179 recommendations were classified within each of these three areas. The General Objective, Functional Area, and Technical Objective addressed by each recommendation are listed in parentheses following its documentation in Appendix A. All 179 recommendations were also classified according to the actions they call for. The particular action each recommendation calls for is listed in square brackets following its documentation in Appendix A. The tallies from these classifications are shown in Table 3.

As Table 3 shows, most of the recommendations concern the DMSO General Objectives of Management and Investment; most of the recommendations concern the DMSO Functional Areas of Education, Training, and Military Operations and Analysis; and most of the recommendations concern the DMSO Technical Objective of Methodology. Most of the actions called for by the recommendations concern management improvements.

1. General Objectives

All 179 recommendations were categorized according to which single General Objective they concern. These results concerning DMSO General Objectives are discussed in more detail in Appendix B. The three General Objectives for DMSO are the following:

a. Management

DMSO should (1) establish a DoD-wide management structure to coordinate joint modeling and simulation activities and requirements for their use and (2) promote coordination across DoD components to minimize duplication in modeling and simulation developments efforts and to increase productivity through combined efforts.

Table 3. Tallies from Four Classifications of the Modeling and Simulation Recommendations

	Recommendations	
	Number	Percent
General Objectives		
Management	90	50
Policy	14	8
Investment	75	42
Total	179	
Functional Areas		
Education, Training, and Military Operations	63	35
Research and Development	23	13
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Application Area	29	16
Targeted Research and Development	34	19
Technical Improvement	39	22
Modeling and Simulation Development	12	7
Management Improvement	45	25
Coordination	20	11
Total	179	

Ninety (50 percent) of the 179 recommendations concern the General Objective of Management. The Management recommendations by themselves are about evenly split between the Functional Areas of Education, Training, and Military Operations on one hand (34 percent) and Analysis (37 percent) on the other. Most of the Management recommendations concern the Technical Objective of Methodology (67 percent).

b. Policy

DMSO should (1) promulgate and oversee the implementation of a DoD modeling and simulation policy; (2) develop policy in specific areas necessary to ensure the effective joint application of models and simulations; (3) fix responsibilities to ensure the proper oversight of models and simulations with joint applicability; and (4) furnish guidance for the consistent development of modeling and simulation plans by the DoD components.

Fourteen (8 percent) of the 179 recommendations concern the General Objective of Policy. Most of the Policy recommendations concern the Test and Evaluation Functional Area (50 percent) and the Technical Objective of Methodology (71 percent).

c. Investment

DMSO should (1) formulate and implement a long-range joint investment strategy for models and simulations and (2) identify and fund high-priority investments leading to enhanced joint modeling and simulation capabilities.

Seventy-five (42 percent) of the 179 recommendations concern the General Objective of Investment. These recommendations are about evenly split between the Functional Areas of Education, Training, and Military Operations (40 percent) on one hand and Analysis (37 percent) on the other. Most of the Policy recommendations concern the Technical Objective of Methodology.

2. Functional (Application) Areas

All 179 recommendations were categorized according to which single Functional Area in DMSO they concern. The results concerning DMSO Functional (Application) Areas are discussed in more detail in Appendix C. The 5 Functional Areas are the following:

a. Education, Training, and Military Operations (ET&MO)

These applications emphasize modeling and simulation applications for training in joint military operations. They also include modeling and simulation applications such as the re-creation of historical battles, doctrine and tactics development, command and unit training, operational planning and rehearsal, and wartime situation assessments.

Sixty-three (35 percent) of the 179 recommendations concern modeling and simulation applications in Education, Training, and Military Operations. These recommendations are about evenly split between the General Objectives of Management

(49 percent) and Investment (48 percent). Most of them concern the Technical Objective of Methodology (81 percent).

b. Research and Development (R&D)

These applications include modeling and simulation applications such as the definition of requirements, support for engineering design, and assessments of system performance. They focus on articulating the requirements of the research and development community and managing its activities. They concern modeling and simulation applications that are used for exploration by scientists and engineers and that support the needs of the research and development community.

Twenty-three (13 percent) of the 179 recommendations concern modeling and simulation applications in Research and Development. Most of these recommendations concern the General Objective of Management (57 percent) and the Technical Objective of Methodology (52 percent).

c. Test and Evaluation (T&E)

These applications include modeling and simulation applications such as early operational assessments, design of operational tests, and excursion and sensitivity analyses. They focus on modeling and simulation applications that enhance the quality of test and evaluation end products by overcoming test impediments and test resource limitations.

Twenty-four (13 percent) of the 179 recommendations concern modeling and simulation applications in Test and Evaluation. Most of these recommendations concern the General Objective of Management (46 percent) and the Technical Objective of Methodology (75 percent).

d. Analysis

These applications include modeling and simulation applications such as campaign analyses, assessing force structure, determining system configuration determination, and cost analyses. They focus on modeling and simulation applications that inform decisions concerning the development of Defense operational capabilities.

Sixty-five (36 percent) of the 179 recommendations concern modeling and simulation applications in Analysis. These recommendations are evenly split between the

General Objectives of Management (51 percent) and Investment (43 percent) and emphasize the Technical Objective of Methodology (60 percent).

e. Production and Logistics (P&L)

These applications include modeling and simulation applications such as system producibility assessments, industrial base appraisals, and determinations of logistics requirements. They focus on modeling and simulation applications that support procuring, maintaining, and transporting Defense materiel, personnel, and facilities.

Only four (2 percent) of the 179 recommendations concern modeling and simulation applications in Production and Logistics. Two address the General Objective of Management and two concern Investment; all four address the Technical Objective of Methodology.

3. Technical Objectives

All 179 recommendations were categorized according to which single Technical Objective they concern. These results concerning DMSO Technical Objectives are discussed in more detail in Appendix D. The four Technical Objectives are the following:

a. Architectural Development

This objective is to develop and promulgate standards that promote the interoperability of modeling and simulation components. It concerns architectural structures that allow interoperability and sharing of assets and specification of interface standards to support the modeling and simulation user communities.

Only one recommendation concerns Architectural Development. It addresses the General Objective of Investment and the Functional Area of Education, Training, and Military Operations.

b. Methodological Development

This objective is to develop and promulgate databases, tools, and methodologies for community-wide use. It focuses on the conceptual bases and procedures for the verification, validation, and accreditation of models and simulations.

One hundred twenty-three (69 percent) of the 179 recommendations concern Methodology. The closeness with which these recommendations are linked to methodological considerations in modeling and simulation varies widely. These

recommendations are evenly split between the General Objectives of Management (60 percent) and Investment (52 percent) and between the Functional Areas of Education, Training, and Military Operations (51 percent) on one hand and Analysis (38 percent) on the other.

c. Advanced Technologies

This objective is to develop and promulgate key technologies for supporting modeling and simulation. These technologies include computer hardware, software engineering, graphics displays, and behavioral representation.

Advanced Technology could reasonably be combined with Methodology as a Technical Objective, but it is kept separate for this analysis. Eighteen (10 percent) of the 179 recommendations concern Advanced Technology. These recommendations emphasize the General Objective of Investment (78 percent) and the Functional Area of Research and Development (50 percent).

d. Information Sharing

This objective is to develop and promote coordination and communication across and within the Defense modeling and simulation communities.

Information Sharing could reasonably be combined with Methodology as a Technical Objective, but it is kept separate for this analysis. Thirty-seven (21 percent) of the 179 recommendations concern Information Sharing. These recommendations emphasize the General Objective of Management (73 percent) and the Functional Area of Analysis (62 percent).

4. Recommended Actions

All 179 recommendations were categorized according to the actions they call for. These results concerning Recommended Actions are discussed in more detail in Appendix E. The six recommended actions are the following:

a. Application Area

Recommendations for applications of modeling and simulation to new areas of activity or expansions of existing applications where the emphasis was on the area of application and not on the development of new or expanded modeling and simulation capabilities were classified as application recommendations.

Many study panels, addressing various issues of military policy and practice, have recommended modeling and simulation as means to resolve these issues. Twenty-nine (16 percent) of the 179 recommendations concern either applications of modeling and simulation to new areas of activity or expansions of the use of modeling and simulation in already existing areas of application.

b. Targeted Research and Development

Recommendations for research and development of new or expanded capabilities for modeling and simulation where the emphasis was on the new or expanded capabilities and not on new or expanded areas of applications for modeling and simulation were classified as research and development recommendations.

Many study panels have noted requirements for increased capabilities in the technology of modeling and simulation. Thirty-four (19 percent) of the 179 recommendations concern research and development of new or expanded capabilities. About two-thirds of these recommendations concern specific capabilities that should be developed, and about one-third concern the management of programs to accomplish these ends.

c. Technical Improvement

Recommendations for improvements in the conduct of modeling and simulation activities that primarily require better use of existing technical capabilities rather than the development of new ones were classified as recommendations for technical improvements.

Many study panels have noted requirements to extend application of existing technical capabilities in the conduct of modeling and simulation. Thirty-nine (22 percent) of the 179 recommendations concern improvements that require better use of existing technical capabilities.

d. Modeling and Simulation Development

Recommendations for improvements in the design and development of models and simulations were classified as recommendations for modeling and simulation preparation.

Twelve (7 percent) of the 179 recommendations concern improvements in the design and development of models and simulations. Almost all of these recommendations concern the development of models and simulations used in the acquisition, test, and evaluation of other systems.

e. Management Improvement

Recommendations for improvements in the conduct, control, and use of modeling and simulation were classified as recommendations for management improvements.

Forty-five (25 percent) of the 179 recommendations concern improvements in the way modeling and simulation activities are conducted, controlled, and used.

f. Coordination

Recommendations for coordinating under single management or in a single location modeling and simulation activities or resources such as algorithms and databases were classified as recommendations for coordination and centralization.

Twenty (11 percent) of the 179 recommendations concern the coordination of modeling and simulation activities or resources under under single management or in a single location. These coordination recommendations are a subset of the management improvements discussed above.

E. COMMON THEMES

Some common themes run through these 179 recommendations and across most of the 16 years in which they were made. These themes include:

- *Increased information sharing and feedback.* Defense management should provide greater cooperation and information sharing on the development, implementation, maintenance, verification, validation, and accreditation of Defense models and simulations (1) within each of the Services, (2) among the Services, the Joint Staff, and the CINCs, and (3) between the U.S. Defense establishment and its allies.
- *Higher level management responsibility.* Management responsibility for models and simulations should be raised to senior levels of the Services and Joint Staff. Without this level of attention and responsibility, different and perhaps inconsistent assumptions and methods will continue to be used to make critical decisions concerning Defense policy and procedures. Responsibility for quality, control, and dissemination of models and simulations and of their data, algorithms, and resources should be more coordinated and centralized.
- *Broadened perspective.* The general perspective on how and where modeling and simulation technology should be applied should be extended to new areas and broadened within existing areas of application. Military science should be fully integrated in the development and use of Defense models and simulations.

- *Systematic planning*. The requirements, resources, and responsibilities for Defense modeling and simulation should be systematically developed, documented, and reviewed, periodically revised, and then used to guide management of Defense modeling and simulation. Deficiencies in Defense modeling and simulation should be identified and prioritized, applicable technology should be forecast, and this information should be systematically applied to guide investments in Defense modeling and simulation.
- *Improved technology*. Significant opportunities exist for improving the technology of both modeling and simulation. Specific investments can and should be made to improve the basic technology of modeling and simulation, for instance by developing and integrating accurate factors for human performance in models and simulations, devising computer tools for developing and testing models and simulations, developing intelligent computer based adversaries, developing joint threat simulators, reducing controller requirements, and increasing simulation portability.
- *Improved technical quality*. Significant opportunities exist for improving the technical quality of Defense modeling and simulation. Specific investments can and should be made to raise the technical quality of models and simulations, for instance, by incorporating instructional technology into flight simulators, improving the statistics, distributions and assessment routines used in many models, ensuring assignment of qualified personnel to modeling and simulation positions, exploiting commercial developments such as new graphics capabilities, distributed computing, and networking, allowing remote participation by non-collocated participants including U.S. allies, requiring third party and/or senior review of models and simulations, and increasing the interoperability of Defense models and simulations.
- *Increased application in system acquisition, test, and evaluation*. This single area of application is mentioned so often across the recommendations that it deserves separate presentation. Modeling and simulation should be used early and repeatedly in system acquisition to improve our understanding of how new systems will perform in combat before they are committed to prototyping.
- *New and extended applications*. Specific investments can and should be made to extend modeling and simulation to new areas and within existing areas of application such as crew, group, team, and unit training, military operations in built up areas, combat service support planning, ground attack munitions, echelon above corps,[1] and joint warfare.

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[1] Discussions of echelon above corps (EAC) modeling usually focus on the need for joint simulation. It should be noted that joint operations can be performed at any level, not just at echelons above corps, that recommendations of this sort may be motivated as much by a desire for joint simulation as for high-level simulation, and that these recommendations may be looking for two fairly independent capabilities, not just one.

F. CONCLUSIONS

This review has been primarily descriptive, but it suggests the following conclusions:

- Interest in Defense modeling and simulation is widespread and persistent. Many study panels have recommended the application of modeling and simulation to many areas. This widespread interest is evident across all 16 years of study panels summarized here. Additionally, many study panels have been given as their primary topic some aspect of Defense modeling and simulation.
- There are substantial needs and opportunities for sharing information, capabilities, and resources within and among the Defense modeling and simulation communities. This conclusion is based on the frequency with which recommendations for sharing of information, capabilities, and resources are made by senior study panels.
- More attention should be paid to the verification, validation, and accreditation of Defense models and simulations. Many recommendations addressed the desirability of increased explicit and impartial verification and validation of Defense models and simulations.
- Some specific areas of Defense modeling and simulation development and implementation deserve more attention, such as the architectural issues of interoperability and specification of interface standards for modeling and simulation. Given the current interest in networking simulations and in linking different models and simulation together, attention to architectural issues seems likely to grow. There has also been little attention given to systematic life-cycle support of models and simulations themselves and more is needed.
- There are substantial needs and opportunities for improving the technologies underlying Defense modeling and simulation. The frequency with which technical improvements are recommended by senior study panels strongly suggests that there are many technical opportunities and improvements to be pursued and that these opportunities have been overlooked by the Defense modeling and simulation communities.
- There are many areas to which modeling and simulation either should be applied anew or extended. Most prominent among these areas are those associated with acquisition--"simulate before you buy" and applying simulation through every stage of the acquisition process. However, the wide range of other application areas recommended suggests that there are at least some, if not many, new areas to which modeling and simulation should be applied such as logistics and combat engineering.

- Many study panels have focused almost exclusively on either simulator technology or computerized wargaming. Substantial work remains to be done to build consensus and collegiality and to unite people concerned with either modeling or simulation into a coordinated community prepared to address the problems of warfighting.
- Joint applications of modeling and simulation receive emphasis chronologically late in the stream of recommendations considered here, but this later emphasis is substantial and frequent. Joint warfighting represents a significant area for increased use of modeling and simulation technology.
- There are substantial needs and opportunities for improving management and coordinated development of Defense modeling and simulation activities. The fact that such recommendations have been made repeatedly suggests by itself the need for attention from senior management.
- Together, the recommendations for coordination and information sharing suggest a need to develop standards that permit ready sharing of data and resources among models, simulations, and simulators and to allow them to be networked.

Finally, it should be noted that most of the recommendations reviewed here came from study panels sponsored either by OSD organizations or the Army and that the above themes and conclusions are based primarily on recommendations made to these sponsors. Recommendations from other sponsors, especially those in the Navy and Air Force, were not found through the standard channels used to locate information for this review.

APPENDIX A
MODELING AND SIMULATION RECOMMENDATIONS

1. [ASB, 1991] *ARMY SCIENCE BOARD 1991 SUMMER STUDY ON ARMY SIMULATION STRATEGY* (AUGUST 1991). WASHINGTON, DC: ARMY SCIENCE BOARD. (DRAFT) [SPONSORED BY THE DEPUTY UNDER SECRETARY OF THE ARMY FOR OPERATIONS RESEARCH]

Overall

- The Secretary of the Army and the Chief of Staff should assure that the Army proceeds into the Electronic Battlefield era as rapidly and enthusiastically as possible.

  (Policy, ET&MO, Methodology) [Technical Improvement]

- The Electronic Battlefield program should be funded at the Department of the Army level. It should have a single manager with a direct mandate from the Secretary of the Army.

  (Management, ET&MO, Methodology) [Coordinate]

- In the future the development of major materiel systems should normally involve experimentation and testing using electronic prototypes at every stage of development from requirements generation to testing of production articles. Testing of electronic systems on the Electronic Battlefield will not obviate the need for testing of actual articles in the real environment. The two should become parts of a complementary process that is far superior to that which has been done before.

  (Management, T&E, Methodology) [Application]

Training on the Electronic Battlefield

- The Army should review the current structure of the Electronic Battlefield program.

  (Management, ET&MO, Methodology) [Management Improvement]

- The Army should enthusiastically adopt electronic training as a major part of its training strategy.

  (Policy, ET&MO, Methodology) [Application]

- The Army should be willing to trade-off OPTEMPO as well as other funds to finance the new modes of training.

  (Management, ET&MO, Methodology) [Management Improvement]

- The Army should adopt a combined arms simulation strategy from the outset and should look for a scheme that will provide at least a combined arms capability at the Battalion Command Field Exercise level at the earliest possible moment.

  (Investment, ET&MO, Methodology) [Technical Improvement]

- The Army should fund these programs at the Department of the Army level and should undertake cost effective actions that build on existing SIMNET hardware and software.

  (Management, ET&MO, Methodology) [Targeted R&D]

Development and Testing on the Electronic Battlefield

- The Army should mandate the use and sharing of electronic prototyping through all stages of system development. Refined versions should be provided back to the combat developers for their continued use and participation with the materiel development community, as system definition proceeds. Physical testing should only be used for limited confirmation tests in key areas and for testing (such as reliability) that cannot reasonably be conducted with the electronic prototype.

  (Policy, T&E, Methodology) [Application]

Managing the Electronic Battlefield

- A single manager should be put in charge of the Electronic Battlefield--its design, fielding, and operation--as a service system to be used by the numerous Army customers. Two existing programs, CATT and BDS-D, should be combined by making them extensions of the Electronic Battlefield. The manager should also resolve issues of whether and how to upgrade SIMNET or to retire it as the current plan envisages. The Army should use this manager as a key point of contact on distributed simulation with similar managers in other services and with the new Defense Modeling and Simulation Office. This manager should be a flag officer PEO whose office is a small, lean management cell supported by other parts of the Army and assisted in the day-to-day operation of the system by contractors or possibly an FFRDC.

  (Management, ET&MO, Methodology) [Coordinate]

Data Base and Model Quality

- The Army should develop a process and discipline to ensure quality of data across the total spectrum of model use. This should be a prime task for the manager of the Electronic Battlefield. A limited number of databases and models will be widely used in the Electronic Battlefield. The Electronic Battlefield manager should assure that these are "certified" to ensure validity and consistency. Other databases and models may be made available for use centrally from the Electronic Battlefield even though they are not officially "certified" so that new concepts can be introduced for examination and testing before they are validated.

  (Management, ET&MO, Methodology) [Coordinate]

Technology Investment Strategy

- Because of the existing strong commercial impetus for technology development, the Army should utilize technology advances made in the outside world. It should adopt a strategy of exploiting technology that is developed elsewhere and should not invest in technology development for modeling and simulation except for specific Army-unique needs.

  (Policy, R&D, Advanced Technology) [M&S Development]

2. [FM&P, 1990] *SIMULATION POLICY STUDY* (1990). WASHINGTON, DC: OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE (FORCE MANAGEMENT AND PERSONNEL) AND OFFICE OF THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING.

- Set as your objective interoperable, distributed M&S capable of depicting STRATEGIC FORCE PROJECTION, consistent with the Defense Policy Guidance, whether for regional contingencies, or for reconstituting theater defenses in Europe or the Northwest Pacific. Invest to support the CINCs of the combatant commands of the United States, for since U.S. force will fight only under their command, M&S should reflect that reality. Invest to reconfigure M&S to adapt rapidly to new threats and unanticipated contingencies. Invest to treat in M&S the Reserve Components as mainline elements of the Total Force.

  (Investment, Analysis, Methodology) [Targeted R&D]

- Approve and implement the EXCIMS/DMSO management scheme. Assign DARPA immediate action, pending approval and staffing, and plan for DARPA's passing overall management to the DMSO not later than start of FY 1992, while remaining the lead OSD actor in R&D. We estimate this will require 5 to 10 percent of available funds.

  (Management, R&D, Methodology) [Management Improvement]

- Invest 15 percent of your available M&S funds in basic research to bring to DoD's M&S the best mathematical paradigms, analytical methods, and interoperability techniques available in America's universities, laboratories, and industry.

  (Investment, R&D, Methodology) [Targeted R&D]

- Invest 15 percent of your M&S funds in enabling technologies: more powerful, cheaper processors, graphic displays, data base construction, and communications.

  (Investment, R&D, Advanced Technology) [Technical Improvement]

- Invest 60 percent of your available M&S funds to develop a prototype, transportable, hybrid representation of an operational theater that draws on empirically-derived representation of the behavior of actual physical and human systems. Observations of that behavior should be sought in actual operations, in operational tests, or in training exercises that most closely replicate the complexities and frictions of battle, such as large-scale Tactical Engagement Simulation (TES). Use the most effective mathematics to model such behaviors, incorporate actual equipment whenever it is cost effective to do so and aim at consistency across models, simulations, and operations: per the present term of art, *seamless simulation*.

  (Investment, ET&MO, Methodology) [Targeted R&D]

- Task the Director, DARPA, to undertake immediately the investments outlined above, drawing on the funds now available, and securing cooperation with the components to insure meshing new starts with existing and near-term systems, smooth fielding of prototypes, and managing new products through their life-cycle.

  (Management, R&D, Methodology) [Targeted R&D]

- Establish, in concert with the Joint Chiefs of Staff, policies to assure full integration of military science with the acquisition of future M&S, including provision for educating military service personnel in M&S developments and applications.

  (Policy, Analysis, Methodology) [Management Improvement]

3. **[DSB, 1989] *REPORT OF THE DEFENSE SCIENCE BOARD TASK FORCE ON IMPROVING TEST AND EVALUATION EFFECTIVENESS* (DECEMBER 1989). WASHINGTON, DC: DEFENSE SCIENCE BOARD. [SPONSORED BY THE UNDER SECRETARY OF DEFENSE FOR ACQUISITION]**

For the role of models and simulations in the evaluation process:

- The Service acquisition executives should ensure that M/S excursion analyses are applied systemically to help reach and maintain agreement on major aspects of requirements and system performance.

  (Management, T&E, Methodology) [Application]

- The DOT&E and Service OT&E communities should be chartered to participate early in the requirements process. In particular, they should translate operational requirements into an evaluation framework and document the roles for M/S as well as for testing in meeting evaluation objectives at each milestone and as appropriate between milestones.

  (Policy, T&E, Methodology) [Application]

- The USD(A) should establish policy and provide guidance to the acquisition community for systematically re-evaluating system specifications using M/S and test results.

  (Policy, T&E, Methodology) [Application]

- Service acquisition executives should ensure that the development programs employ man-in-the-loop simulation beginning with requirements definition and mature the simulation along with the hardware throughout the acquisition process.

  (Management, T&E, Methodology) [Application]

- JCS/CINCs should exploit technology capabilities in distributed computing and networking to simulate coordinated combined arms engagements with man-in-the-loop simulations and to evaluate results against live exercises.

  (Investment, T&E, Advanced Technology) [Technical Improvement]

For the credibility of models and simulations:

- USD(A) should ensure refinement, maintenance, and availability of models, weapon and threat data descriptions, and simulation elements having wide DoD utility.

  -- Appropriate JCS and OSD offices should select/fund executive agents to maintain element repositories (DNA-Nuclear models, DIA-Threat data,

JTCGs, etc.) complete with databases, code libraries, and documented limitations.

(Policy, T&E, Information Sharing) [Coordinate]

- USD(A) should charter DDR&E to enable, as necessary, independent panels of experts to assess specific applications of M/S results on which acquisition decisions are based. The work would be tasked on a case-by-case basis and include participants from academia, industry, and the government.

  (Management, T&E, Methodology) [Management Improvement]

- USD(A) should modify DoDI 5000.2 to require that DAB documentation (SCP/DCP, TEMP, COEA and CAIG) address the applicability of models and simulation. For example, the documentation could consider the M/S plan and methodology, limitations, assumptions, extrapolations, sensitivities, results, analysis, and validation.

  (Policy, T&E, Methodology) [Management Improvement]

- DDR&E should continue to fund M/S technology at both the fundamental and application levels, including the M/S interfaces and languages, executable specifications, model interoperability, validation techniques and tools, and parallel and networked simulations.

  (Investment, R&D, Methodology) [Targeted R&D]

4. [ASB, 1989] *FINAL REPORT OF THE AD HOC SUBGROUP ON CLOSE COMBAT (HEAVY) TRAINING STRATEGY FOR THE 1990'S* (MARCH 1989). WASHINGTON, DC: ARMY SCIENCE BOARD. [SPONSORED BY THE ASSISTANT SECRETARY OF THE ARMY FOR RESEARCH, DEVELOPMENT, AND ACQUISITION] AD-B134 12L

- Training for different echelons needs to be reconciled and stabilized. DCSOPS and MACOMS should place increased emphasis on command and staff simulations and training without troops to allow higher echelons to train up prior to field exercises.

  (Management, ET&MQ, Methodology) [Technical Improvement]

- The philosophy "train as you fight" requires access to realistic battlefield conditions to achieve the motivation and discipline to perform well under stressful combat conditions. New technology additions and insertions properly analyzed, integrated, and applied selectively have the potential for improvement in heavy force readiness, particularly for the Reserve

Components (RC). Use of networked simulation that is applicable to both the Active Component (AC) *and* RC should be expanded.

(Management, ET&MO, Advanced Technology) [Targeted R&D]

- Combat training for the RC needs further alteration and tailoring to fit the unique RC environments. DCSOPS should re-examine the applicability of AC training devices to RC needs and circumstances, and increase the level of RC combat training, based on prioritized needs of specific RC units, through increased and integrated use of simulation, networking, and specific RC-oriented training devices.

  (Management, ET&MO, Methodology) [Technical Improvement]

- The effectiveness of various combinations of training (live-fire, maneuver, simulation) is not being determined objectively. TRADOC should establish field and simulator test-beds and supporting simulation models for new training strategies, devices, and techniques comparable to or coordinated with materiel testing facilities.

  (Management, ET&MO, Methodology) [Technical Improvement]

- Manprint does not influence training adequately during materiel acquisition. DCSPER, TRADOC, and AMC should re-examine the role and implementation of Manprint during systems acquisition to insure the appropriate use of engineering simulations as test-beds to identify and reduce excessive training burdens of new and modified equipment.

  (Management, ET&MO, Methodology) [Management Improvement]

5. [IG, 1989] *WARGAMING ACTIVITIES IN THE DEPARTMENT OF DEFENSE* (REPORT NO. 89-057) (MARCH 1989). WASHINGTON, DC: OFFICE OF THE INSPECTOR GENERAL, DEPARTMENT OF DEFENSE.

- We recommend that the Assistant Secretary of Defense for Force Management and Personnel participate in establishing policies and procedures on wargaming and similar activities--including simulations, modeling, and exercises--that define wargaming and clarify responsibilities and relationships of DoD schools, colleges, and training centers involved in joint wargaming activities.

  (Management, ET&MO, Methodology) [Management Improvement]

- We recommend that the Director, Joint Staff, prepare and staff a decision paper for the Chairman, Joint Chiefs of Staff, to:

  -- Designate an office of primary responsibility within the Joint Staff to establish policies and procedures on wargaming and similar activities--

including simulations, modeling, and exercises--that define wargaming and clarify responsibilities and relationships of DoD schools, colleges, and training centers participating in joint wargaming activities. These policies and procedures should include provisions to oversee, monitor, and coordinate the acquisition of facilities, computer systems, computer models, data bases, and other developments related to wargaming, simulations, exercises, and other defined and specified operational responsibilities and missions.

(Management, ET&MO, Methodology) [Coordinate]

-- Discontinue operations at the Joint Warfare Center and transfer management oversight responsibilities (now assigned to the Joint Warfare Center) to the Joint Staff.

(Investment, Analysis, Methodology) [Management Improvement]

-- Initiate actions with the Assistant Secretary of the Army for Financial Management and the Comptroller of the Air Force to discontinue funding the operations of the Joint Warfare Center, and adjust the Five-Year Defense Plan accordingly.

(Investment, Analysis, Methodology) [Management Improvement]

- We recommend that the Deputy Chief of Naval Operations for Naval Warfare:

  -- Direct the Naval War College to request a waiver from the Joint Staff to allow the development, testing, and analysis of operational war plans and contingency plans for the Chief of Naval Operations. If denied, direct the College to discontinue its support to testing and analysis of plans.

  (Management, Analysis, Methodology) [Management Improvement]

  -- Stop constructing Sensitive Compartmented Information Facilities at Naval Schools, colleges, and training centers when wargaming activities are limited to education and training.

  (Investment, ET&MO, Methodology) [Management Improvement]

- We recommend that the Air Force Deputy Chief of Staff for Plans and Operations:

  -- Direct the Air Force program management office to prepare memorandums of agreement and joint management plans to ensure that any further development of the Command Readiness Exercise System is coordinated with other Service schools, colleges, and training centers.

  (Management, ET&MO, Information Sharing) [Management Improvement]

-- Direct the Air Force program management office to make requirements for developing the Command Readiness Exercise System consistent with the Joint Chiefs of Staff policy on the distribution of operational war plans and contingency plans to ensure that, if appropriate, a waiver to this policy is granted before development of the Command Readiness Exercise System is continued.

(Management, Analysis, Methodology) [Management Improvement]

- We recommend that the Commander in Chief, U.S. European Command:

-- Direct the Warrior Preparation Center to prepare an updated management plan specifying the objectives of wargaming activities, the operating procedures, and the requirements for facilities and computer systems necessary to effectively manage wargaming activities there.

(Management, ET&MO, Methodology) [Management Improvement]

-- Initiate actions with the Assistant Secretary of the Army for Financial Management and the Comptroller of the Air Force to discontinue the $40 million in funding required by the Warrior Preparation Center to expand its facilities, to procure computer systems (hardware and software), and to develop computer models. Adjust the Five-Year Defense Plan accordingly.

(Investment, ET&MO, Methodology) [Management Improvement]

-- Prepare and staff a decision paper for the Secretary of Defense to coordinate the appropriate organization and command structure for the Warrior Preparation Center to ensure that the U.S. Army, Europe; the U.S. Naval Forces, Europe; and the U.S. Air Forces in Europe are included in wargaming exercises held at the Center.

(Management, ET&MO, Information Sharing) [Management Improvement]

-- Initiate actions to have a memorandum of understanding executed with the Supreme Allied Commander, Europe, that ensures that the U.S. Government is reimbursed by the North Atlantic Treaty Organization nations that participate in wargaming exercises at the Warrior Preparation Center.

(Management, ET&MO, Information Sharing) [Management Improvement]

6. **[DSB, 1988] *REPORT OF THE DEFENSE SCIENCE BOARD TASK FORCE ON COMPUTER APPLICATIONS TO TRAINING AND WARGAMING* (MAY 1988). WASHINGTON, DC: DEFENSE SCIENCE BOARD. [SPONSORED BY THE UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING] AD-A199 456**

- **Make joint simulations interoperable.** Internet existing Service, college, training center, and joint games and simulations for education and training. Evolve them to be distributed, so that commanders and staffs can train from their duty stations in peace or wartime. Use one standard DoD communication protocol, and use cost-effective communications hardware and software.

  (Investment, ET&MO, Architecture Development) [Technical Improvement]

- To facilitate the sharing of simulation data, create a shared repository, a library of automated, validated data descriptions for simulation use. Make the data descriptions available DoD-wide. To ensure the quality and timeliness of data, each data description should be built and maintained by the organization/service that is most knowledgeable about the data.

  (Management, ET&MO, Information Sharing) [Coordinate]

- **Promote joint simulation usage.** Continue and extend the involvement of the most-senior joint commanders in battle simulations. The CINCs should be supported as they obtain required joint simulation capabilities, particularly on-station capabilities.

  (Management, ET&MO, Methodology) [Application]

- **Establish requirements for future capabilities.** Establish long-term joint training simulation requirements. Document them in JCS directives and use these requirements to develop and issue guidance for future system designs, substantive enhancement of current systems, development of technical standards for gaming, training and simulation, and management of a simulation-prototype program.

  (Management, ET&MO, Methodology) [Management Improvement]

- **Establish a prototype program.** Establish a continuing program to demonstrate exploratory prototype simulations, followed by rapid acquisition of selected capabilities. The program should monitor technology advances and selectively build experimental prototypes. The joint users should be closely involved. Selected, prototype-proven capabilities should be rapidly fielded.

  (Investment, R&D, Advanced Technology) [Targeted R&D]

- **Undertake a major joint training initiative.** Institutionalize the management and budget in OJCS to oversee: the immediate internetting of existing assets, enhanced joint simulation use, increased use of joint assets for testing war plans and joint doctrine, creation of the shared data repository, and implementation of the rapid prototype program. CJCS should coordinate spaces, program elements, and budget lines--both joint and in the Services--to arrive at more effective simulation-based training with less development redundancy.

  (Management, ET&MO, Information Sharing) [Application]

7. **[GAO, 1988] *ELECTRONIC WARFARE: MULTIPLE DEVELOPMENT OF COSTLY THREAT SIMULATORS* (GAO/NSIAD-88-93) (FEBRUARY 1988). WASHINGTON, DC: GENERAL ACCOUNTING OFFICE. AD-A190 349**

- The Secretary of Defense should:
  - -- Assure that the EXCOM and Crossbow-S or other appropriate DoD elements execute responsibility and authority for centrally managing simulator programs to provide for timely identification and consolidation of simulator requirements and for disapproval of programs representing unwarranted development.

    (Policy, Analysis, Methodology) [Coordinate]
  - -- Require the services to strengthen internal controls over simulator acquisitions by segregating responsibilities for development, testing, and acceptance of simulators as valid representations of the threat.

    (Management, Analysis, Methodology) [Management Improvement]
  - -- Assign to an appropriate DoD element the responsibility for monitoring the quality of simulators acquired and participating in the acquisition process as necessary to assure the adequacy of simulators.

    (Management, Analysis, Methodology) [Coordinate]

8. **[ASB, 1988] *ARMY SCIENCE BOARD FINAL REPORT OF THE AD HOC SUBGROUP ON THE USE OF ARMY COMBAT MODELS FOR THE ANALYSIS AND TRAINING OF JOINT/COMBINED OPERATIONS* (JANUARY 1988). WASHINGTON, DC: ARMY SCIENCE BOARD. [SPONSORED BY THE DEPUTY UNDER SECRETARY OF THE ARMY FOR OPERATIONS RESEARCH] AD-B120 937**

Joint Scenarios and Data

- Army should consider use of multiple scenarios for analysis, e.g., III Corps insertion in NORTHAG.

  (Investment, Analysis, Methodology) [Targeted R&D]

- Scenarios should include dynamics of the onset of battle conditions.

  (Investment, Analysis, Methodology) [Technical Improvement]

- Establish joint USA-USAF and USA-USN analysis steering groups to guide analysis, model/model developments, and scenarios/databases.

  (Management, Analysis, Information Sharing) [Technical Improvement]

- Army should reconsider limits to data exchange with NATO allies.

  (Policy, Analysis, Information Sharing) [Management Improvement]

Joint Campaign Models

- Develop an EAC (Echelon Above Corps) model by enhancing VIC via a "prototyping" process.

  (Investment, Analysis, Methodology) [Targeted R&D]

- Replace assessment routines in training models with those used in analysis models.

  (Investment, ET&MQ, Methodology) [Technical Improvement]

- Establish an Army models committee peer review of Army models/model developments. Encourage a similar activity in USAF, JCS, CENTCOM, RECOM.

  (Management, Analysis, Information Sharing) [Management Improvement]

- Model developments should employ an evolutionary, prototyping strategy, not a "bold-leap" strategy.

  (Management, R&D, Methodology) [Technical Improvement]

Joint Campaign Analysis and Training

- DUSA(OR) should establish an Army analysis improvement program.

  (Investment, Analysis, Methodology) [Technical Improvement]

- Do not use wargame training models as analysis vehicles, although they can identify important issues for analysis.

  (Management, Analysis, Methodology) [Management Improvement]

- DUSA(OR) should take a leadership position with the JCS-8 regarding Army analysis.

  (Policy, Analysis, Methodology) [Management Improvement]

Recommendations on Targeted Issues

Army and Air Force Coordination of Campaign Modeling and Analysis

- The VCSA should approach the VCSAF to form a joint analysis steering group at the headquarters level. The group should be responsible for stimulating and oversight of cooperative efforts in campaign modeling and analyses where deemed appropriate.

  (Management, Analysis, Information Sharing) [Coordinate]

- As a first effort, the group should formulate a joint study to compare the structures, data, and output of the TAC THUNDER, FORCEM, and VIC models (with particular emphasis on assumptions, employment logic, assessment routines) and develop a program to resolve major disparities. Further, it should consider the development of mutually agreeable scenarios and a joint data base for analyses.

  (Investment, Analysis, Information Sharing) [Coordinate]

Army and Marine Corps/Navy Coordination of Campaign Modeling and Analysis

- Chief of Staff Army and Chief of Naval Operations (CSA/CNO) should initiate a relationship of the kind which led to the Chief of Staff AF/CSA agreement to examine specific areas of mutual cooperation in planning.

  (Management, Analysis, Information Sharing) [Coordinate]

- As a first effort CSA/CNO should develop several test scenarios of joint warfare, one examining a typical contingency situation where Marines and Army units operate together and another where Army electronic counter-

measures (ECM), electronic counter-countermeasures (ECCM) battlefield needs are provided by the Navy until Army assets arrive.

(Investment, Analysis, Information Sharing) [Application]

- VCSA should approach Vice CNO (VCNO) to form a HQ-level joint analysis steering group similar to that recommended for the VCSA and VCAF. Additionally, the VCSA and VCNO should establish a joint ASB, Naval Research Advisory Council Task Team to recommend the appropriate level of USN/USA cooperation in analysis.

  (Management, Analysis, Information Sharing) [Management Improvement]

Army and Allied Forces Coordination of Campaign Modeling and Analysis

- The Army should improve its consideration of combined forces in its analysis of U.S. defense issues and of combined issues. It could begin by learning more about and (where useful) exploiting analyses performed by SHAPE (Supreme Headquarters Allied Powers, Europe) Technical Center (STC). Adequate consideration of combined issues will require the U.S. to take a proactive position to open up the exchange of data with the allies, particularly weapon system performance data.

  (Investment, Analysis, Information Sharing) [Technical Improvement]

Implications to the Army of the JCS Reorganization and Packard Commission

- In view of the expanded charter of the JCS, DUSA(OR) should take a leadership position for the Army to ensure the continuation of a strong liaison with J-8 during both the formative period and the long term.

  (Management, Analysis, Information Sharing) [Coordinate]

- It is recommended that the Joint Analysis Steering Group should take the lead in fostering the development of joint inputs for submission to J-8, not only to provide assistance but also to share confidence that joint Army/Air Force views are considered.

  (Management, Analysis, Information Sharing) [Management Improvement]

- Quality Army personnel should be made available for assignment to J-8 to ensure that solid Army experience is provided and that ground-force considerations are properly represented. Specifically, it is recommended that the ORSA Advisory Committee be charged with the responsibility for seeing to it that premium Army analysts are channeled into J-8. The Committee should

also carefully monitor the assignment of Army analysts to the staffs of the Unified Commands.

(Management, Analysis, Information Sharing) [Management Improvement]

Coupling the CINCs' Needs

- The Army analysis community should be attuned to the thinking of CINCs and aware of current Operations Plans (OPLANS) so that this thinking can be embodied in the future scenarios, threats, and data which are used in Army analyses. This should be coordinated with JCS and the MAPP.

  (Management, Analysis, Information Sharing) [Technical Improvement]

- DUSA(OR) should endeavor to have the Army analysis community participate with J-8 JCS in supporting the CINCs needs.

  (Management, Analysis, Information Sharing) [Management Improvement]

Adequacy of Scenarios for Joint/Combined Analysis and Training

- The DUSA(OR) should form an ad hoc team to review this issue (adequacy of joint scenarios) and suggest appropriate scenarios and a process to ensure their consideration.

  (Investment, Analysis, Methodology) [Technical Improvement]

Campaign Models for Analysis of Joint Operations

- Army should develop a multi-corps-to-Army-group automated simulation. TRAC should enhance VIC for this purpose using a prototyping process. Then use the model for analysis of most joint issues.

  (Investment, Analysis, Methodology) [Application]

- Enhance representation of tactical air processes in FORCEM. Expand scope where necessary. Use for analysis of theater-level, force structure, logistics, and major resource allocation joint issues.

  (Investment, Analysis, Methodology) [Targeted R&D]

- Wargame models are best used in broad identification of issues and development of insights. Wargame models such as MTM, JTLS, and JESS should not be used for the evaluation of alternative solutions or sensitivity analyses.

  (Management, Analysis, Methodology) [Management Improvement]

Adequacy of Data for Joint/Combined Analysis

- Require all Army models to use, to the maximum extent possible, measurable data generated by Army and Air Force laboratories for the assessment routines. DUSA(OR) should audit compliance with this recommendation.

  (Management, Analysis, Information Sharing) [Technical Improvement]

Army Campaign Analysis Process

- The analysis process of studying all the component parts of the simulated campaign results in detail to learn *why* the more macro results occurred and to verify that they are correct is not a school-learned ability. The Army must recognize this training requirement and make a conscious effort to provide this training to its analysis staffs through the formation and implementation of an "Army Analysis Improvement Program" (AAIP) using senior level analysts as trainers.

  -- Establish an Army analysis improvement program.

  (Management, ET&MO, Methodology) [Management Improvement]

  -- ODUSA(OR) select 5-10 studies annually for close personal participation resulting in mentoring and technical review.

  (Investment, ET&MO, Methodology) [Management Improvement]

- As noted, it takes many years to learn how to verify the correctness of a simulated campaign run and to extract meaningful insights and trends from multiple runs. Maintaining a small number of joint analysis teams doing continual analysis of airland campaign issues (rather than forming a new team for each study question) would facilitate this learning. The Army should formulate and implement a research program to see if an "Intelligent Analyzer" expert system can be developed which captures the analysis process used by recognized senior experienced analysts and could be used in training less experienced ones and possibly support the analysis activity.

  -- Require analyses be performed by *teams* comprised of analysts, modelers who know the details of the model used, data specialists, and relevant military operational specialists.

  (Management, Analysis, Methodology) [Management Improvement]

  -- Have TRADOC establish a proactive cell of analysts and operations/ doctrine experts to perform continuous analysis of joint/combined tactics, operations, and doctrine. This cell should be designated as the Army's overall agency for coordination of joint operations in Army analysis.

  (Investment, Analysis, Methodology) [Management Improvement]

-- Initiate research to develop an "intelligent analyzer" expert system and "analytic analog" campaign models.

(Investment, Analysis, Advanced Technology) [Targeted R&D]

- Parametric analysis is an integral part of any Army analysis project. Recognizing that time and resource constraints may preclude the number of parametric variations one would like in a study, the Army should initiate a program to develop and test "analytic analog" campaign models that can mimic the more detailed corps and Echelons Above Corps (EAC) ones for *interpolative* sensitivity analysis. (Examples of this concept include the COMAN, BLDM, AFAADS-GUN, MACRO, and other analytic models.)

  -- Require parametric analysis in study directives.

  (Management, Analysis, Methodology) [Technical Improvement]

  -- Require briefings and reports to highlight key variables, assumptions, FTC that are "high drivers."

  (Management, Analysis, Methodology) [Management Improvement]

Campaign Models for Training in Joint and Allied Operations

- Model-based training may provide valuable practice and experience in warfighting for commanders and staffs. It should continue to be resourced. However, it is imperative that the simulation algorithms be significantly improved. The assessment routines in MTM, JTLS, and JESS should be replaced by those used by the Army corps-level analysis models, perhaps with some analytic modifications to reduce run times.

  (Investment, ET&MO, Methodology) [Technical Improvement]

- The Army should expedite the process of providing a responsive, EAC training model for use by senior commanders.

  (Investment, ET&MO, Methodology) [Application]

Credibility of Some Campaign Models

- The DUSA-OR should form a DA level group comprised of senior experienced professionals to structure and implement procedures for peer review and scrutiny of Army campaign models (and possibly campaign analyses). The Army should strongly encourage the establishment of similar groups in DoD organizations outside the Army--especially the Air Force and JCS--who routinely use simulation models for analysis and training which involve Army forces.

  (Management, Analysis, Methodology) [Coordinate]

- Exposure to the professional community is a generic mechanism for peer review and scrutiny of scientific/technical work. Models used in Army joint studies should be used, *and be technically understood*, by multiple agencies. All models used for analysis or training of Army forces should use or have a direct audit trail to objective measurable data generated by Army and Air Force laboratories for their assessment routines.

  (Management, Analysis, Information Sharing) [Management Improvement]

Coordination of Army Campaign Modeling Efforts

- Army models committee should coordinate and review all the Army's ongoing campaign modeling EFF efforts.

  (Management, Analysis, Information Sharing) [Management Improvement]

- Model development should be evolutionary and iterative in conjunction with studies. Do not repeat AMIP "bold-leap" strategy.

  (Management, R&D, Methodology) [Technical Improvement]

- VCSA and DUSA(OR) should ensure that AMIP funding is maintained.

  (Management, Analysis, Methodology) [Technical Improvement]

- AMC should expand the Army Model Management Office's (AMMO) mission to include execution of joint/combined modeling developments.

  (Management, Analysis, Methodology) [Management Improvement]

Opportunity for Senior Officer Exercises

- Adopt a primary, simulation-based EAC senior officer training model. Candidates include VIC (enhanced) (Issue #7) or more rapid versions of JTLS, JESS (expanded) and FORGE.

  (Investment, ET&MO, Methodology) [Application]

- WPC concept should be fostered in unified commands and senior service colleges.

  (Management, ET&MO, Methodology) [Technical Improvement]

- Army should fully support Air University "Joint Flag Officer War Fighting Course," and examine a similar capability.

  (Investment, ET&MO, Methodology) [Application]

Available Technology Opportunities for Improvement of Campaign Modeling and Analysis

- AMC should expedite efforts to simplify and speed up process of developing computer model input/output through use of model subset libraries and relational databases.

  (Investment, Analysis, Methodology) [Technical Improvement]

- AMC, as a matter of priority, should procure contemporary high-speed data processing equipment for its analytic agencies--failing in this, authorize contemporary equipment rental.

  (Investment, Analysis, Advanced Technology) [Technical Improvement]

- AMC should focus on the adaptation of commercial graphics improvements to aid input/output data interpretation.

  (Investment, Analysis, Methodology) [Technical Improvement]

- AMC should evaluate NATO Panel VII concerns and, if appropriate, develop distributed wargames/models to allow remote participation by operational commands and non-collocated analysts.

  (Investment, Analysis, Information Sharing) [Targeted R&D]

- AMC should establish properly resourced and integrated artificial intelligence cells at analytic agencies, to include LANL.

  (Investment, Analysis, Advanced Technology) [Targeted R&D]

- Within the context of the modeling R&D Plan, Army Model Management Office (AMMO) should investigate artificial intelligence to enhance pre-/post-processors, enhance sensitivity analysis, better represent red and blue commands, and provide modular staffs in models.

  (Investment, Analysis, Advanced Technology) [Targeted R&D]

- HQDA AI Center address the apparent lack of transportability in diverse AI hardware and software.

  (Management, Analysis, Information Sharing) [Technical Improvement]

Basic Research Program in Campaign Modeling and Analysis

- AMC should conduct a model deficiency analysis and prioritization.

  (Investment, R&D, Advanced Technology) [M&S Development]

- AMC should conduct a modeling-related technology forecast.

  (Investment, R&D, Advanced Technology) [M&S Development]

- AMMO should design the research program resulting from this forecast and deficiency analysis.

  (Management, R&D, Advanced Technology) [Targeted R&D]

- AMC should designate AMMO as the manager of this research program, with AMC guidance and personnel augmentation.

  (Management, R&D, Advanced Technology) [Targeted R&D]

- AMC should expand AMMO's mission, to include coordinating research with external agencies, such as Defense Advanced Research Project Agency (DARPA), JCS, RAND, national labs and academia.

  (Management, R&D, Information Sharing) [Management Improvement]

- DUSA(OR) should recommend that DARPA host a semi-annual joint modeling research seminar.

  (Management, R&D, Information Sharing) [Management Improvement]

- VCSA and DUSA(OR) should ensure that AMIP and SIMTECH funding is maintained or expanded.

  (Management, R&D, Methodology) [Technical Improvement]

9. [GAO, 1987] *DOD SIMULATIONS: IMPROVED ASSESSMENT PROCEDURES WOULD INCREASE THE CREDIBILITY OF RESULTS* (GAO/PEMD-88-3) (DECEMBER 1987). WASHINGTON, DC: GENERAL ACCOUNTING OFFICE. AD-A191 503

- GAO recommends that the Secretary of the Department of Defense adopt or develop and implement guidance on producing, validating, documenting, managing, maintaining, using, and reporting simulations of weapon-system effectiveness. This guidance should include a way of routinely providing reviews of a simulation's credibility and, in this way, identifying problems that should be resolved. The Secretary should explore requiring that a statement regarding validation efforts accompany simulation results.

  (Management, Analysis, Methodology) [M&S Development]

- GAO also recommends that the Secretary of the Department of Defense direct the agencies responsible for managing the ADAGE, CARMONETTE, and COMO III models to explore the feasibility of correcting the limitations GAO has identified, especially the limitations in validation.

  (Management, Analysis, Methodology) [Technical Improvement]

10. **[DSB, 1986] *CONFLICT ENVIRONMENT TASK FORCE (IMPLICATIONS OF THIRD WORLD URBAN INVOLVEMENT)* (MAY 1986). WASHINGTON, DC: DEFENSE SCIENCE BOARD. [SPONSORED BY THE UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING] AD-A171 677**

Longer Term Mission Preparedness

- The Corps of Engineers should conduct and contract for games, simulations, and exercises to clarify and identify requirements.

  (Investment, Analysis, Methodology) [Application]

- The Secretary of Defense and the Chairman of the Joint Chiefs of Staff should:

  -- Institutionalize "from the beginning" intelligence community participation in Third World operations planning and pertinent games, simulations, and exercises.

  (Management, ET&MO, Information Sharing) [Technical Improvement]

  -- Task the Services to institutionalize on-going education and training, simulations, and games on Third World conflicts with urban control and management aspects in the Service academies and the command and staff colleges.

  (Investment, ET&MO, Methodology) [Application]

11. **[ASB, 1985A] *ARMY SCIENCE BOARD FINAL REPORT OF THE 1985 SUMMER STUDY ON TRAINING AND TRAINING TECHNOLOGY--APPLICATIONS FOR AIRLAND BATTLE AND FUTURE CONCEPTS* (DECEMBER 1985). WASHINGTON, DC: ARMY SCIENCE BOARD. [SPONSORED BY THE DEPUTY CHIEF OF STAFF OF THE ARMY FOR OPERATIONS] AD-B101 040L**

Battle Simulation

- TRADOC should sustain training battle simulation improvement programs. Align training simulation models more closely with model structures used for analysis (i.e., use of detailed process descriptions).

  (Investment, ET&MO, Methodology) [Technical Improvement]

- TRADOC should incorporate new technologies to reduce controller requirements and increase simulation portability.

  (Investment, ET&MO, Advanced Technology) [Targeted R&D]

- ODCSOPS should fund and AMC/TRADOC accelerate SIMNET development and explore potential to connect SIMNET with larger Battle Simulations.

  (Investment, ET&MO, Methodology) [Targeted R&D]

- TRADOC should increase the emphasis on managing the conduct of unit training in Army Officer/NCO institutional training.

  (Management, ET&MO, Methodology) [Application]

Leadership

- ODCSOPS/TRADOC develop and make available to the General Officer a specifically tailored computerized warfighting game providing the opportunity for personal rapid experimentation in the operational art/tactics of AirLand Battle (ALB) doctrine.

  (Investment, ET&MO, Methodology) [Application]

Validation of Training System Components

- TRADOC should establish a panel of training technologists to identify training DSM&Ps (Devices, Simulations, Methods, and Practices) requiring validation through controlled testing or other techniques; then fully support such evaluations.

  (Management, ET&MO, Methodology) [Technical Improvement]

- Agencies responsible for the design, conduct, and reporting of validation tests should be adequately staffed, and their efforts subjected to independent review by peers responsible to the DA Staff.

  (Management, ET&MO, Methodology) [Management Improvement]

12. [DSB, 1985] *IMPROVING THE ACQUISITION MANAGEMENT PROCESS FOR CONVENTIONAL MUNITIONS, FOCUSING ON GROUND ATTACK MUNITIONS (U)* (NOVEMBER 1985). WASHINGTON, DC: DEFENSE SCIENCE BOARD. [SPONSORED BY THE UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING] (SECRET)[1] AD-C037 912

- Continue improving the analytical models used for the determination of conventional munitions acquisition objectives.

  (Investment, Analysis, Methodology) [Application]

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1 Although this report is classified, both its title and the recommendation listed here are unclassified.

13. **[ASB, 1985B] *ARMY SCIENCE BOARD FINAL REPORT OF THE 1985 SUMMER STUDY ON MANNING IMPLICATIONS OF LOGISTICS SUPPORT FOR AIRLAND BATTLE* (OCTOBER 1985). WASHINGTON, DC: ARMY SCIENCE BOARD. [SPONSORED BY THE DEPUTY CHIEF OF STAFF OF THE ARMY FOR PERSONNEL AND THE DEPUTY CHIEF OF STAFF OF THE ARMY FOR LOGISTICS] AD-A163 385**

Data Bases/Modeling

Adequate and accurate technical documentation, data bases, and logistics models are required to define and subsequently meet AirLand battle combat service support logistics requirements.

- TRADOC/AMC should institute procedures to ensure adequate funding and to discipline the requirement for RAM/ILS programs during development of new systems, product improvement programs, and acquisition of non-developmental items (NDI).

  (Management, P&L, Methodology) [Technical Improvement]

- TRADOC/AMC should develop and institute a streamlined logistics data base program, oriented toward the needs of CSS force structure planners with a payoff for the user.

  (Investment, P&L, Methodology) [Targeted R&D]

- AMC, emphasizing simplicity, should standardize and rigorously discipline field logistics data collection efforts, e.g., redefine the data formats for LSA and SDC as standards.

  (Management, P&L, Methodology) [Technical Improvement]

- DCSOPS should develop CSS force structure planning models which are structured to reflect specific, dynamic, operational scenarios, and DCSLOG account for the productivity gains available through workload aggregation.

  (Investment, P&L, Methodology) [Targeted R&D]

14. **[ASB, 1983] *ARMY SCIENCE BOARD (ASB) 1983 SUMMER STUDY ON THE FUTURE DEVELOPMENT GOAL* (NOVEMBER 1983). WASHINGTON, DC: ARMY SCIENCE BOARD. [SPONSORED BY THE ASSISTANT SECRETARY OF THE ARMY FOR RESEARCH, DEVELOPMENT, AND ACQUISITION] AD-A135 819**

Combined Arms Training Strategy

- TRADOC should devise a training strategy to develop leaders and units for airland battle (ALB).
  - -- Publish specific combined arms tactics (to include CS, CSS, and other services) to implement ALB doctrine at corps, division, and brigade.
  - -- Identify training facility requirements and needed improvements.
  - -- Identify requirements for improved training games, simulations, devices, etc.

  (Management, ET&MQ, Methodology) [Application]

15. **[JDL, 1983] *REPORT OF THE JOINT DIRECTORS OF LABORATORIES TECHNOLOGY INITIATIVE PANEL FOR TRAINING AND SIMULATION* (JULY 1983). (AFHRL-TP-83-30). BROOKS AFB: AIR FORCE HUMAN RESOURCES LABORATORY. AD-B082 764**

- It is recommended that the JDL direct implementation of a joint program with Air Force lead to establish a Joint Services Visual Simulation Research (VSR) Program for initiation of university research efforts to stimulate innovations in visual/imaging simulation technology, with possible new breakthroughs and new architectures in training simulators.

  (Investment, R&D, Advanced Technology) [Targeted R&D]

- It is recommended that the Services continue to support the Hermann model of a tri-Service training and simulation R&D center of excellence with close university relations in Orlando, FL.

  (Investment, R&D, Advanced Technology) [Coordinate]

- It is recommended that the JDL direct guidance to their respective Service laboratories:
  - -- To develop vertically integrated technology demonstrations that are field deployable for collective readiness training in units, especially in command-and-control training and in wargaming.

  (Investment, R&D, Methodology) [Targeted R&D]

-- To appoint ad hoc teams to identify and assess possible applications of existing training and simulation technology to selected operational training programs.

(Management, R&D, Methodology) [Application]

16. **[GAO, 1983] *BETTER PLANNING AND MANAGEMENT OF THREAT SIMULATORS AND AERIAL TARGETS IS CRUCIAL TO EFFECTIVE WEAPON SYSTEMS PERFORMANCE* (GAO/MASAD-83-27) (JUNE 1983). WASHINGTON, DC: GENERAL ACCOUNTING OFFICE. AD-A129 851**

- The Secretary of Defense should:

  -- Require the Director, DT&E, to enforce existing requirements for the preparation and approval of weapon system TEMPs (Test and Evaluation Master Plans) before the demonstration/validation and subsequent decision milestones.

  (Policy, T&E, Methodology) [M&S Development]

  -- Require predemonstration/validation phase TEMPs to state whether or not test resource requirements are available, and outline what actions have been or need to be taken to develop or acquire those not available. In addition, the effect of being unable to test against the full threat spectrum should be clearly identified.

  (Management, T&E, Methodology) [M&S Development]

  -- Require operational test and evaluation agencies to state in the initial TEMP their ability (or inability) to adequately assess a weapon's operational suitability and effectiveness, given currently available test resources. The adequacy of test resources and the effect of inadequate or incomplete testing should be clearly spelled out.

  (Management, T&E, Methodology) [M&S Development]

  -- Require electronic warfare and aerial target test resource developers to work closely with the weapons developers and test agencies during early test planning to identify the critical test resources needed to fully assess weapon system effectiveness.

  (Management, T&E, Methodology) [M&S Development]

  -- Transfer Navy and Air Force threat simulator and aerial target acquisition responsibility to an organization separate from the weapon systems development activity. The gaining organization should have, as does the Army's threat simulator organization, the independence, authority,

responsibility, and funds to ensure the successful acquisition of test resources.

(Management, T&E, Methodology) [Coordinate]

-- Establish a joint-Service threat simulator and aerial target improvement program to identify, time phase, and prioritize DoD-wide test resource deficiencies; and start development of the resources necessary to match the test capability with current requirements.

(Investment, T&E, Information Sharing) [Coordinate]

-- Initiate a review of intelligence support to identify the underlying causes and to solve the problems of inadequate support to the threat simulator development community. In particular, the appropriateness of Defense Intelligence Agency assignments to the Service intelligence organizations and the capability of those organizations to support both weapons designers and the test community should be examined and changes made where appropriate.

(Investment, T&E, Information Sharing) [Management Improvement]

17. [DSB, 1982A] *REPORT OF THE DEFENSE SCIENCE BOARD 1982 SUMMER STUDY PANEL ON TRAINING AND TRAINING TECHNOLOGY* (NOVEMBER 1982). WASHINGTON, DC: DEFENSE SCIENCE BOARD. [SPONSORED BY THE UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING] AD-A127 596

Organization and Management Section

- Recommendation: Increase use of analytical methods to (a) assess/project impact of manpower pool on new weapons systems and (b) identify where training may increase skills/performance of recruits to meet system needs, do not wait for more analysis/assessment. There are enough data to proceed now.
- Action: ASD(MRA&L) establish policy that will require design tradeoffs and contractor assessments early in the weapon system development phases to identify their impact on weapon system design and skill performance requirements. Manpower and training projections be used to identify impact on weapon system design and skill performance requirements.

  (Management, ET&MO, Methodology) [Technical Improvement]

Planning and Application Section

- Recommendation: Support research, development, and use of war games that provide intelligent adversaries and realistic conditions to promote effective combat leadership training.
- Action: USDRE provide guidance to Military Departments to increase emphasis for research, development and implementation of campaign battle and engagement simulation for purposes of leadership training.

(Investment, ET&MO, Advanced Technology) [Targeted R&D]

Technology Section

- Recommendation: Increase exploration and use of current/advanced technology devices (e.g., arcade-like games and simulations) to motivate and teach functional skills.
- Action: USDRE provide guidance to Military Departments to increase funds to explore use of such devices. Funds to come from other than Personnel and Training R&D programs.

(Investment, ET&MO, Advanced Technology) [Targeted R&D]

18. [DSB, 1982B] *DEFENSE SCIENCE BOARD SUMMER STUDY (1982) PANEL ON NEW WEAPONS CONCEPTS* (NOVEMBER 1982). WASHINGTON, DC: DEFENSE SCIENCE BOARD. [SPONSORED BY THE UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING] AD-C030 727

- USDRE require the Services to make more extensive use of models and simulations in evaluating the military worth and costs of systems--"simulate before decide."

(Management, Analysis, Methodology) [Application]

19. [DDRE, 1982] *USDRE INDEPENDENT REVIEW OF DOD LABORATORIES* (MARCH 1982). WASHINGTON, DC: OFFICE OF THE UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING. AD-A118 006

- The creation of a private sector organization as a core work force for the development of long-term, professional quality in simulation techniques.

(Management, R&D, Methodology) [Coordinate]

20. **[ASB, 1981] *ARMY SCIENCE BOARD AD HOC SUBGROUP ON TESTING OF ELECTRONIC SYSTEMS* (SEPTEMBER 1981). WASHINGTON, DC: ARMY SCIENCE BOARD. [SPONSORED BY THE ASSISTANT SECRETARY OF THE ARMY FOR RESEARCH, DEVELOPMENT, AND ACQUISITION] AD-A123 265**

Systems Development

- Additional effort should be devoted to the concept definition/concept evaluation/advanced development phases of system development; additional consideration should be given to early system simulation and to tradeoffs among performance and reliability/availability/maintainability; in this connection, Army in-house capability as "wise buyers" should be improved.

  (Management, T&E, Methodology) [Application]

Software Design and Testing

- Based on the system specifications, and with flexibility in agreed areas, automated, computer-based test tools should be developed to drive (via simulation and stimulation) the engineering and initial production models of software-intensive systems; only in this way can operational environments be suitably represented in a reproducible fashion.

  (Investment, T&E, Methodology) [M&S Development]

- To facilitate cost-effective software testing with results that can be uniformly interpreted and "graded," a common library of software verification and validation tools should be developed and used on an Army-wide basis; the Army should recognize an opportunity to provide (DoD) leadership in this regard.

  (Investment, T&E, Information Sharing) [Technical Improvement]

Time to Develop and Deploy

- It is suggested that consideration be given to a radical change in the development/testing process, in recognition of the special characteristics of software-intensive systems; that the computer-based test tools required to represent the test (tactical) environment be provided by a contractor other than the system development contractor, in parallel with system development. In this approach, the testing/user activities should participate in the test contractor design reviews--and should be required to quantify and document test requirements.

  (Policy, T&E, Methodology) [M&S Development]

- The indicated test drivers (environment simulators) should be developed for particular programs; however, they can be appropriately integrated into the plans for testing at various facilities.

  (Management, T&E, Information Sharing) [M&S Development]

- The development of the test drivers should be in accordance with the disciplines previously outlined for software development and testing.

  (Investment, T&E, Methodology) [M&S Development]

Interoperability Testing

- More extensive over-all planning should be carried out; and considered decisions should be made relative to the omission of testing for reasons of complexity or cost. In this regard, it is especially important that analyses and simulations be conducted to guide decisions, with recognition of the fact that appropriate complementary employment of systems can greatly enhance over-all Army combat effectiveness.

  (Management, T&E, Methodology) [Application]

21. [GAO, 1980] *MODELS, DATA, AND WAR: A CRITIQUE OF THE FOUNDATION FOR DEFENSE ANALYSES (GAO/PAD-80-21)* (MARCH 1980). WASHINGTON, DC: GENERAL ACCOUNTING OFFICE. AD-A086 708

- We recommend the Secretary of Defense require the Chairman, Joint Chiefs of Staff, to review current procedures for safeguarding and strengthening the empirical-theoretical foundation underlying the analytic representation of combat in Defense studies. This should include:

  -- Identifying the empirical-theoretical limitations of such studies as are employed in high-level Defense decision-making; and

  (Investment, Analysis, Methodology) [Targeted R&D]

  -- Ascertaining the extent to which military and civilian defense analysts are aware of the empirical validity of their tools, and the existing corpus of knowledge pertaining to their projects.

  (Management, Analysis, Information Sharing) [Management Improvement]

- And, as warranted by that review, to prepare plans and recommendations which would enable the Organization of the Joint Chiefs of Staff to serve as the Defense Establishment's principal analytic adviser on matters pertaining to the

phenomenology of combat. Such plans and recommendations should consider the requirements for:

-- Developing adequate theories and empirical information about the integrative structures of combat which bind the Services together in a web of common concern and interests.

(Investment, Analysis, Information Sharing) [Management Improvement]

-- Making recommendations to the Secretary of Defense on priorities for research, and on preferred theories and criteria to be used in defense analyses; and

(Management, R&D, Methodology) [Management Improvement]

-- Establishing an institutional focus to provide the Defense analytic community with (1) a senior adviser, (2) a corporate memory, (3) a technical forum, and (4) a center to disseminate information on the techniques of combat analysis.

(Management, Analysis, Information Sharing) [Coordinate]

22. [ASB, 1980] *ARMY SCIENCE BOARD AD HOC STUDY GROUP REPORT ON HUMAN ISSUES* (MARCH 1980). WASHINGTON, DC: ARMY SCIENCE BOARD. [SPONSORED BY THE ASSISTANT SECRETARY OF THE ARMY FOR RESEARCH, DEVELOPMENT, AND ACQUISITION] AD-A091 285

- The Army should task a full-time organizational element within the staff that will have authority to integrate and coordinate human issues policy development, research, analysis, and modeling activities. The group would serve the purpose of elevating human issues considerations and combining them with high level policy determinations. It would become the major proponent for human issues model development and applications within the Army. It would focus on Army needs rather than respond to OSD impetus. This organization must receive high level support and have the authority and proper mix of expertise to do its job effectively. We suggest that it be assigned at either the Chief of Staff or Deputy Chief of Staff level.

  (Management, Analysis, Methodology) [Coordinate]

- The Army should develop holistic Force Composition models rather than narrow single purpose models. Human dimensions such as fatigue and cohesiveness must be quantified and included in the Army's hierarchy of Force Effectiveness models. The study group is convinced that Force Effectiveness models that include human dimensions can be developed. Further, we believe

that hard-to-quantify human characteristics can be quantified and included. The study group endorses the Army's hierarchical approach to combat effectiveness modeling. However, we urgently feel that the human dimension must be given full consideration in development of each element in the hierarchy.

(Investment, Analysis, Methodology) [Targeted R&D]

- The Army should establish a center of excellence for human issues modeling. This center should be the focal point for modeling the human component of Force Effectiveness and for collecting test data necessary to support modeling activities. The function of this center would be to relate current and future research findings [on such human issues as fatigue, leadership, cohesiveness, morale, and motivation] to maintaining high levels of readiness, enhancing combat effectiveness, predicting alternative outcomes, and providing relevant human resource management considerations for policy development. The academic community and industry should be solicited for inputs and assistance in improving the state-of-the-art of such modeling technology.

  (Management, R&D, Methodology) [Coordinate]

- The Army should coordinate its efforts [to develop integrated Force Composition models] with those of the other Services to eliminate duplication and to further modeling technology through an active interchange of ideas.

  (Management, Analysis, Information Sharing) [Management Improvement]

23. [ASB, 1979] *MILITARY OPERATIONS IN BUILT-UP AREAS (MOBA)* (JANUARY 1979). WASHINGTON, DC: ARMY SCIENCE BOARD. [SPONSORED BY THE ASSISTANT SECRETARY OF THE ARMY FOR RESEARCH, DEVELOPMENT, AND ACQUISITION] AD-B034 309

- MOBA modeling, simulation, and training plans and activities should consider the broad range of MOBA; namely, CIC, operations involving the combination of man-made towns and the surrounding natural terrain, and MOUT.

  (Management, ET&MO, Methodology) [Application]

- Field and simulation studies should proceed simultaneously so that each can benefit from the findings of the other.

  (Management, ET&MO, Information Sharing) [Technical Improvement]

- Continue the development of URBWAR as a platoon-vs-platoon, single assault, short time duration, shot-by-shot model, incorporating into it those features of other small-unit-action simulations felt beneficial and the capability for at least parametric treatment of other factors such as CBR. Some of this

development will have to wait for the results of field tests or additional changes made as new knowledge becomes available.

(Investment, ET&MO, Methodology) [Targeted R&D]

- Use URBWAR to develop appropriate distributions and statistics for higher level simulations, models, and war games.

  (Investment, ET&MO, Methodology) [Technical Improvement]

- Continue to develop MOBACS as new information becomes available from field tests and new subroutines are developed or adopted from other simulation models.

  (Investment, ET&MO, Methodology) [Technical Improvement]

- Investigate the use of intercorrelations in the development of the statistical battlefield in the MOBACS terrain model as a means of increasing the realism in representing street networks and building complexes.

  (Investment, ET&MO, Methodology) [Targeted R&D]

- Develop a comprehensive CIC model of sufficient resolution to investigate such factors as squad-level tactics, the details of weapon usage, interrelationships among the environment, tactics, and weapons, individual detection and firing capability, and psychological factors. This investigation should include examinations of the MOBACS Unit Operations Level Game to check the feasibility of increasing its resolution to the level required and of DYNTACS and perhaps other high resolution simulations to see if they can be adapted to MOBA.

  (Investment, Analysis, Methodology) [Application]

- Using the expertise gained by CAC in their MOBA study, modify (expand) SCORES to include MOBA.

  (Investment, Analysis, Methodology) [Targeted R&D]

- Investigate the appropriateness of modifying JIFFY or perhaps other interactive corps level simulations for use as a MOBA MOUT model and as a high level training device.

  (Investment, ET&MO, Methodology) [Targeted R&D]

- Continue the dissemination of current MOBA doctrine and related material in field manuals and training documents and provide for the rapid update of these publications as new and improved information becomes available.

  (Investment, ET&MO, Methodology) [Technical Improvement]

- Investigate the use of the MOBACS map exercise and Force Operations Level Game as MOBA training devices for corps and division commanders. Its

interactive nature should make it well suited for this purpose. Should this not prove feasible, JIFFY and other high level models would have to be considered. If no existing high-level model can be adapted to do the job, a new game would have to be developed from scratch.

(Investment, ET&MO, Methodology) [Application]

- Appropriate training materials and inputs to the high level MOBA game should be prepared for use by corps and division commanders. The following subjects should be included: (1) the use or urbanized terrain as a force multiplier, (2) the use of combined arms at the corps level in urbanized terrain, (3) consideration of political, religious, and humanitarian factors, including the effects of collateral damage, in planning military operations, and (4) the administration of non-combatants in occupied areas, in particular where fighting is taking place.

  (Investment, ET&MO, Methodology) [Targeted R&D]

- A MOBA training facility should be planned for construction and modification on a continuing basis as knowledge of MOBA operations and training requirements increases. An immediate capability should, however, be provided that will enable field exercises to be performed which enact in real life items which the URBWAR model simulates. This involves a single attack on a defended multi-room building starting either from the street or another building, with platoon-size forces on both sides. Results of the field exercises could then be used to update URBWAR and URBWAR study results used to organize and equip offensive and defensive forces in CIC. A logical next step, as information becomes available, is to provide for a comprehensive company-level CIC operation, eventually with combined arms.

  (Investment, ET&MO, Methodology) [Application]

24. [DSB, 1976A] *REPORT OF THE DEFENSE SCIENCE BOARD TASK FORCE ON TECHNOLOGY BASE STRATEGY* (OCTOBER 1976). WASHINGTON, DC: DEFENSE SCIENCE BOARD. [SPONSORED BY THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING] AD-A032 372

- The panel believes that the successes in aircrew training using these new approaches [part task trainers and full mission simulators] can be extended to a number of other training areas. For example, the development of Crew, Group, Team, and Unit (CGTU) training shows great promise. There seems to be a considerable number of good ideas now in need of further R&D to develop them to a useful state. In view of the potential high payoff, the panel recommends this as a good candidate for increased funding.

  (Investment, ET&MO, Methodology) [Targeted R&D]

25. **[DSB, 1976B] *REPORT OF THE TASK FORCE ON TRAINING TECHNOLOGY* (MARCH 1976). WASHINGTON, DC: DEFENSE SCIENCE BOARD. [SPONSORED BY THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING] AD-A069 852**

Crew/Group/Teams/Unit Training

- Initiate systematic R&D to develop a taxonomy of operational force elements (crews, groups, teams, and units), and on methods for controlling training variables in the context of process-control models. This R&D should have first priority to establish a framework for subsequent, programmatic R&D on CGTU training.

  (Investment, ET&MQ, Methodology) [Targeted R&D]

- Incorporate instructional technology into flight and other simulators to improve the effectiveness of these devices for training, and to increase their utility. The Training Technology R&D elements of NPRDC and NTEC (in the Navy), of ARI (in the Army), and of AFHRL (in the Air Force), should be tasked and funded to develop the instructional technology and the delivery systems to be used with these simulators. These laboratories should also participate in the initial planning for the simulators, with the responsibilities for contributing the training technology implementation and utilization plans.

  (Investment, ET&MQ, Methodology) [Targeted R&D]

APPENDIX B
RECOMMENDATIONS CLASSIFIED BY DMSO GENERAL OBJECTIVE

As Table B-1 shows, 90 (50 percent) of the 179 recommendations concern the General Objective of Management. The Management recommendations are about evenly split between the Functional Areas of Education, Training, and Military Operations on one hand and Analysis on the other. Most of them concern the Technical Objective of Methodology.

Table B-1. Management Objectives

	Recommendations	
	Number	Percent
Functional Areas		
Education, Training, and Military Ops	31	34
Research and Development	13	14
Test and Evaluation	11	12
Analysis	33	37
Production and Logistics	2	2
Total	90	
Technical Objectives		
Architectural Development	0	0
Methodology Development	60	67
Advanced Technologies	3	3
Information Sharing	27	30
Total	90	

Of the 90 Management recommendations:

- 12 recommend extending modeling and simulation technology to targeted areas of application.
- 5 recommend research and development to achieve specifically targeted improvements in modeling and simulation.

- 20 recommend technical improvements to modeling and simulation that require application of technological capabilities already in hand.
- 5 recommend improvements in the processes for developing models and simulations.
- 33 recommend general improvements for managing and providing oversight for modeling and simulation.
- 15 recommend establishment of centers for modeling and simulation or of centralized authority for managing modeling and simulation research, development, and practice.

As Table B-2 shows, 14 (8 percent) of the 179 recommendations concern the General Objective of Policy. Most of the Policy recommendations concern the Test and Evaluation Functional Area and the Technical Objective of Methodology.

Table B-2. Policy Objectives

	Recommendations	
	Number	Percent
Functional Areas		
Education, Training, and Military Ops	2	14
Research and Development	1	7
Test and Evaluation	7	50
Analysis	4	29
Production and Logistics	0	0
Total	14	
Technical Objectives		
Architectural Development	0	0
Methodology Development	10	71
Advanced Technologies	1	7
Information Sharing	3	21
Total	14	

Of the 14 Policy recommendations:

- 4 recommend extending modeling and simulation technology to targeted areas of application.
- None recommends research and development to achieve specifically targeted improvements in modeling and simulation.

- 1 recommends technical improvements to modeling and simulation that require application of technological capabilities already in hand.
- 3 recommend improvements in the processes for developing models and simulations.
- 4 recommend general improvements for managing and providing oversight for modeling and simulation.
- 2 recommend establishment of centers for modeling and simulation or of centralized authority for managing modeling and simulation research, development, and practice.

As Table B-3 shows, 75 (42 percent) of the 179 recommendations concern the General Objective of Investment. These recommendations are about evenly split between the Functional Areas of Education, Training, and Military Operations on one hand and Analysis on the other. Most of them concern the Technical Objective of Methodology.

Table B-3. Investment Objectives

	Recommendations	
	Number	Percent
Functional Areas		
Education, Training, and Military Op	30	40
Research and Development	9	12
Test and Evaluation	6	8
Analysis	28	37
Production and Logistics	2	3
Total	75	
Technical Objectives		
Architectural Development	1	1
Methodology Development	52	69
Advanced Technologies	14	19
Information Sharing	8	11
Total	75	

Of the 75 Investment recommendations:

- 13 recommend extending modeling and simulation technology to targeted areas of application.
- 29 recommend research and development to achieve specifically targeted improvements in modeling and simulation.

- 18 recommend technical improvements to modeling and simulation that require application of technological capabilities already in hand.
- 4 recommend improvements in the processes for developing models and simulations.
- 8 recommend general improvements for managing and providing oversight for modeling and simulation.
- 3 recommend establishment of centers for modeling and simulation or of centralized authority for managing modeling and simulation research, development, and practice.

APPENDIX C
RECOMMENDATIONS CLASSIFIED BY DMSO FUNCTIONAL AREA

As Table C-1 shows, 63 (35 percent) of the 179 recommendations concern modeling and simulation applications in Education, Training, and Military Operations. These recommendations are about evenly split between the General Objectives of Management and Investment. Most of them concern the Technical Objective of Methodology.

Table C-1. Education, Training, and Military Operations Functional Area

	Recommendations	
	Number	Percent
General Objectives		
Management	31	49
Policy	2	3
Investment	30	48
Total	63	
Technical Objectives		
Architectural Development	1	2
Methodology Development	51	81
Advanced Technologies	4	6
Information Sharing	7	11
Total	63	

Of the 63 Education, Training, and Military Operations recommendations:

- 13 recommend extending modeling and simulation technology to targeted areas of application.
- 14 recommend research and development to achieve specifically targeted improvements in modeling and simulation.
- 17 recommend technical improvements to modeling and simulation that require application of technological capabilities already in hand.

- None recommends improvements in the processes for developing models and simulations.
- 14 recommend general improvements for managing and providing oversight for modeling and simulation.
- 5 recommend establishment of centers for modeling and simulation or of centralized authority for managing modeling and simulation research, development, and practice.

As Table C-2 shows, 23 (13 percent) of the 179 recommendations concern modeling and simulation applications in Research and Development. Most of these recommendations concern the General Objective of Management and the Technical Objective of Methodology.

Table C-2. Research and Development Functional Area

	Recommendations	
	Number	Percent
General Objectives		
Management	13	57
Policy	1	4
Investment	9	39
Total	23	
Technical Objectives		
Architectural Development	0	0
Methodology Development	12	52
Advanced Technologies	9	39
Information Sharing	2	9
Total	23	

Of the 23 Research and Development recommendations:

- 1 recommends extending modeling and simulation technology to targeted areas of application.
- 8 recommend research and development to achieve specifically targeted improvements in modeling and simulation.
- 4 recommend technical improvements to modeling and simulation that require application of technological capabilities already in hand.
- 3 recommend improvements in the processes for developing models and simulations.

- 4 recommend general improvements for managing and providing oversight for modeling and simulation.
- 3 recommend establishment of centers for modeling and simulation or of centralized authority for managing modeling and simulation research, development, and practice.

As Table C-3 shows, 24 (13 percent) of the 179 recommendations concern modeling and simulation applications in Test and Evaluation. Most of these recommendations concern the General Objective of Management and the Technical Objective of Methodology.

Table C-3. Test and Evaluation Functional Area

	Recommendations	
	Number	Percent
General Objectives		
Management	11	46
Policy	7	29
Investment	6	25
Total	24	
Technical Objectives		
Architectural Development	0	0
Methodology Development	18	75
Advanced Technologies	1	4
Information Sharing	5	21
Total	24	

Of the 24 Test and Evaluation recommendations:

- 8 recommend extending modeling and simulation technology to targeted areas of application.
- None recommends research and development to achieve specifically targeted improvements in modeling and simulation.
- 2 recommend technical improvements to modeling and simulation that require application of technological capabilities already in hand.
- 9 recommend improvements in the processes for developing models and simulations.

- 3 recommend general improvements for managing and providing oversight for modeling and simulation.
- 2 recommend establishment of centers for modeling and simulation or of centralized authority for managing modeling and simulation research, development, and practice.

As Table C-4 shows, 65 (36 percent) of the 179 recommendations concern modeling and simulation applications in Analysis. These recommendations are evenly split between the General Objectives of Management and Investment and emphasize the Technical Objective of Methodology.

Table C-4. Analysis Functional Area

	Recommendations	
	Number	Percent
General Objectives		
Management	33	51
Policy	4	6
Investment	28	43
Total	65	
Technical Objectives		
Architectural Development	0	0
Methodology Development	39	60
Advanced Technologies	4	6
Information Sharing	22	34
Total	65	

Of the 65 Analysis recommendations:

- 6 recommend extending modeling and simulation technology to targeted areas of application.
- 12 recommend research and development to achieve specifically targeted improvements in modeling and simulation.
- 16 recommend technical improvements to modeling and simulation that require application of technological capabilities already in hand.
- None recommends improvements in the processes for developing models and simulations.
- 24 recommend general improvements for managing and providing oversight for modeling and simulation.

- 7 recommend establishment of centers for modeling and simulation or of centralized authority for managing modeling and simulation research, development, and practice.

As Table C-5 shows, only four (2 percent) of the 179 recommendations concern modeling and simulation applications in Production and Logistics. Two address the General Objective of Management and two concern Investment. All four address the Technical Objective of Methodology.

Table C-5. Production and Logistics Functional Area

	Recommendations	
	Number	Percent
General Objectives		
Management	2	50
Policy	0	0
Investment	2	50
Total	4	
Technical Objectives		
Architectural Development	0	0
Methodology Development	4	100
Advanced Technologies	0	0
Information Sharing	0	0
Total	4	

APPENDIX D
RECOMMENDATIONS CLASSIFIED BY DMSO TECHNICAL OBJECTIVE

Only one recommendation concerns Architectural Development. It addresses the General Objective of Investment and the Functional Area of Education, Training, and Military Operations. It recommends that joint simulations be made interoperable through standardization so that they can be networked and operated from physically dispersed duty stations.

Table D-1. Architectural Development Technical Objective

	Recommendations	
	Number	Percent
General Objectives		
Management	0	0
Policy	0	0
Investment	1	100
Total	1	
Functional Areas		
Education, Training, and Military Ops	1	100
Research and Development	0	0
Test and Evaluation	0	0
Analysis	0	0
Production and Logistics	0	0
Total	1	

As Table D-2 shows, 123 (69 percent) of the 179 recommendations concern Methodology. However, Methodology was a catch-all Technical Objective for many of the recommendations. The closeness with which these recommendations are linked to methodological considerations in modeling and simulation varies widely. These recommendations are evenly split between the General Objectives of Management and Investment and between the Functional Areas of Education, Training, and Military Operations and Analysis.

Table D-2. Methodology Technical Objective

	Recommendations	
	Number	Percent
General Objectives		
Management	60	49
Policy	11	9
Investment	52	42
Total	123	
Functional Areas		
Education, Training, and Military Ops	51	41
Research and Development	12	10
Test and Evaluation	18	15
Analysis	38	31
Production and Logistics	4	3
Total	123	

Of the 123 Methodology recommendations:

- 28 recommend extending modeling and simulation technology to targeted areas of application.
- 25 recommend research and development to achieve specifically targeted improvements in modeling and simulation.
- 27 recommend technical improvements to modeling and simulation that require application of technological capabilities already in hand.
- 8 recommend improvements in the processes for developing models and simulations.
- 26 recommend general improvements for managing and providing oversight for modeling and simulation.
- 10 recommend establishment of centers for modeling and simulation or of centralized authority for managing modeling and simulation research, development, and practice.

Advanced Technology could reasonably be combined with Methodology as a Technical Objective, but it is kept separate for this analysis. As Table D-3 shows, 18 (10 percent) of the 179 recommendations concern Advanced Technology. These recommendations emphasize the General Objective of Investment and the Functional Area of Research and Development.

Table D-3. Advanced Technology Technical Objective

	Recommendations	
	Number	Percent
General Objectives		
Management	3	17
Policy	1	6
Investment	14	78
Total	18	
Functional Areas		
Education, Training, and Military Ops	4	22
Research and Development	9	50
Test and Evaluation	1	6
Analysis	4	22
Production and Logistics	0	0
Total	18	

Of the 18 Advanced Technology recommendations:

- None recommends extending modeling and simulation technology to targeted areas of application.
- 11 recommend research and development to achieve specifically targeted improvements in modeling and simulation.
- 3 recommend technical improvements to modeling and simulation that require application of technological capabilities already in hand.
- 3 recommend improvements in the processes for developing models and simulations.
- None recommends general improvements for managing and providing oversight for modeling and simulation.
- 1 recommends establishment of centers for modeling and simulation or of centralized authority for managing modeling and simulation research, development, and practice.

Information Sharing could reasonably be combined with Methodology as a Technical Objective, but it is kept separate for this analysis. As Table D-4 shows, 37 (21 percent) of the 179 recommendations concern Information Sharing. These recommendations emphasize the General Objective of Management and and the Functional Area of Analysis.

Table D-4. Information Sharing Technical Objective

	Recommendations	
	Number	Percent
General Objectives		
Management	27	73
Policy	2	5
Investment	8	22
Total	37	
Functional Areas		
Education, Training, and Military Ops	7	19
Research and Development	2	5
Test and Evaluation	5	14
Analysis	23	62
Production and Logistics	0	0
Total	37	

Of the 37 Information Sharing recommendations:

- 2 recommend extending modeling and simulation technology to targeted areas of application.
- 1 recommends research and development to achieve specifically targeted improvements in modeling and simulation.
- 8 recommend technical improvements to modeling and simulation that require application of technological capabilities already in hand.
- 1 recommends improvements in the processes for developing models and simulations.
- 17 recommend general improvements for managing and providing oversight for modeling and simulation.
- 8 recommend establishment of centers for modeling and simulation or of centralized authority for managing modeling and simulation research, development, and practice.

APPENDIX E
RECOMMENDATIONS CLASSIFIED BY RECOMMENDED ACTION

The recommendations may be summarized under each of these six areas of recommended action (Table E-1).

Table E-1. Tally of Recommended Actions

	Number	Percent
Actions		
Application Area	29	16
Targeted Research and Development	34	19
Technical Improvement	39	22
Modeling and Simulation Development	12	7
Management Improvement	45	25
Coordination	20	11
Total	179	

1. APPLICATION AREA

Many study panels, addressing various issues of military policy and practice, have recommended modeling and simulation as means for resolving these issues. As Table E-1 shows, 29 (16 percent) of the 179 recommendations concern either applications of modeling and simulation to new areas of activity or expansions of the use of modeling and simulation in already existing areas of application. These applications include at least the following 16 areas:

- Military operations in built up areas (MOBA) [ASB, 1979];
- Determining tradeoffs among performance and the reliability/availability/ maintainability of electronic systems and tests of their interoperability [ASB, 1981];
- Evaluating the military worth and costs of new weapons concepts ("simulate before decide") [DSB, 1982b];
- Selected operation training programs [JDL, 1983];

- Training to develop leaders and units for airland battle [ASB, 1983];
- Determining conventional munitions acquisition objectives [DSB, 1985];
- Officer/NCO institutional training [ASB, 1985a];
- Personal rapid experimentation in the operational art/tactics of airland battle doctrine for General Officers [ASB, 1985a];
- Long term mission preparedness for Third World urban conflicts [DSB, 1986];
- Army, Marine Corps, Navy joint campaigns involving ECM and ECCM [ASB, 1988];
- Multi-corps to Army group simulation for joint operations [ASB, 1988];
- Echelon above corps for senior commander training [ASB, 1988];
- On-station training for CINCs [DSB, 1988];
- Establishing a major joint training initiative coordinated by the Chief, Joint Staff [DSB, 1988];
- Systematic use of excursion analyses (to include man-in-the-loop simulation) in all phases of acquisition, test, and evaluation [DSB, 1989];
- Development of major materiel systems in which simulation using electronic prototypes complements testing the actual articles in the field [ASB, 1991].

2. TARGETED RESEARCH AND DEVELOPMENT

Many study panels have noted requirements for increased capabilities in the technology of modeling and simulation. As Table E-1 (above) shows, 34 (19 percent) of the 179 recommendations concern research and development of new or expanded capabilities. About two-thirds of these recommendations concern specific capabilities that should be developed, and about one-third concern the management of programs to accomplish these ends. These recommendations include development of the following:

- A taxonomy of operational force elements (crews, groups, teams, and units) and of methods for controlling their processes [DSB, 1976b];
- Instructional technology incorporated into simulators to increase their effectiveness and utility [DSB, 1976b];
- Part task trainers and full mission simulators for crew, group, team, and unit training [DSB, 1976a];
- A platoon versus platoon, single assault, short time duration, shot by shot model for military operations in built-up/urban areas [ASB, 1979];

- Interactive, corps level simulation for use in high level training for military operations in built-up/urban areas [ASB, 1979];
- Human dimensions such as fatigue and cohesiveness incorporated into force composition and force effectiveness models [ASB, 1980];
- Identification of the empirical-theoretical limitations of models and data employed in high-level Defense decision making [GAO, 1980];
- Increased use of intelligent adversaries, realistic conditions, and advanced technology (e.g., arcade-like devices and simulations) in training simulations [DSB, 1982a];
- Improved visual and imaging capabilities applied to training simulators [JDL, 1983];
- Combat service support force structure planning models [ASB, 1985b];
- New technologies incorporated in training simulations to reduce controller requirements and increase their portability [ASB, 1985a];
- Accelerated SIMNET development and its connection with larger battle simulations [ASB, 1985a];
- An echelon above corps (EAC) joint campaign model [ASB, 1988];
- An "intelligent analyzer" expert system and "analytic analog" campaign models [ASB, 1988];
- Distributed wargames and models to allow remote participation [ASB, 1988];
- An exploratory program to demonstrate programs to satisfy long-term joint training simulation requirements [GAO, 1988];
- Networked simulation applicable to both active and reserve components for close combat (heavy) training [ASB, 1989];
- Continued funding for modeling and simulation by DDR&E at both the fundamental and application levels [DSB, 1989];
- Rapid adaptation to new threats and unanticipated contingencies and treatment of reserve components as mainline elements in simulation [FM&P, 1990];
- Programs that invest 15 percent of available modeling and simulation funds in basic research [FM&P, 1990];
- Programs that invest 60 percent of available modeling and simulation funds to develop a prototype representation of an operational theater that draws on empirical data derived from physical and human systems [FM&P, 1990];
- Programs funded at the Department of Army level to extend existing SIMNET capabilities [ASB, 1991].

3. TECHNICAL IMPROVEMENT

Many study panels have noted requirements to extend application of existing technical capabilities in the conduct of modeling and simulation. As Table E-1 shows, 39 (22 percent) of the 179 recommendations concern improvements that require better use of existing technical capabilities. Among the technical improvements that have been recommended are the following:

- Field and simulation studies should proceed simultaneously so that each benefits from the other and disseminate their results rapidly in field manuals and training documents [ASB, 1979];
- Develop and provide a common library of software verification and validation tools [ASB, 1981];
- Assess the impact of the manpower pool on new weapons systems and identify where training may increase the performance of new recruits in meeting system needs [DSB, 1982a];
- Discipline the requirement for RAM/ILS during development of new systems and the collection of field logistics data [ASB, 1985b];
- Align training simulation models more closely with models used for analysis [ASB, 1985a];
- Identify devices, simulations, methods, and practices that require validation, then provide it [ASB, 1985a];
- Institutionalize from the beginning intelligence community participation in Third World operations planning, gaming, simulations, and exercises [DSB, 1986];
- Correct noted limitations in validation of ADAGE, CARMONETTE, and COMO III [GAO, 1987];
- Include dynamics of the onset of battle conditions in joint scenarios [ASB, 1988];
- Replace assessment routines in training models with those of analysis models [ASB, 1988];
- Improve the Army's consideration of combined forces in its analyses of U.S. defense issues and combined issues [ASB, 1988];
- Improve consideration of CINCs' needs in Army analyses [ASB, 1988];
- Review the adequacy of joint scenarios, suggest more appropriate ones and a process to ensure their consideration [ASB, 1988];
- Require parametric analysis in study directives [ASB, 1988];

- Improve the assessment routines (e.g., in MTM, JTLS, and JESS) used in warfighting training for commanders and staffs [ASB, 1988];
- Model development should be evolutionary and iterative in conjunction with studies--not "bold leaps" [ASB, 1988];
- Foster the Warrior Preparation Center concept in unified commands and senior Service colleges [ASB, 1988];
- Use model subset libraries and relational databases to simplify and speed up the development of computer models [ASB, 1988];
- Either purchase or authorize rental of contemporary high-speed data processing equipment [ASB, 1988];
- Adapt commercial graphics improvements to aid data interpretation [ASB, 1988];
- Address the apparent lack of transportability in diverse artificial intelligence hardware and software [ASB, 1988];
- Internet, with standardized communication protocols, existing games and simulations for training so that they are accessible from duty stations [DSB, 1988];
- Increase use of command and staff simulations to allow higher echelons to train up prior to field exercises [ASB, 1989];
- Further tailor combat training to the unique requirements of the reserve components through increased use of simulation and networking integrated with those used by the active components [ASB, 1989];
- Establish field and simulator test-beds with supporting simulation models for new training strategies, devices, and techniques comparable to materiel testing facilities [ASB, 1989];
- Ensure the appropriate use of engineering simulations as test-beds to identify and reduce excessive training burdens of new and modified equipment [ASB, 1989];
- Exploit technology opportunities in distributed computing and networking to simulate combined arms engagements coordinated with man-in-the-loop simulations and to evaluate their results against live fire exercises [DSB, 1989];
- Invest 15 percent of modeling and simulation funds in enabling technologies (e.g., more powerful, cheaper processors, graphic displays, improved communications) [FM&P, 1990];
- Adopt a combined arms simulation strategy from the outset [ASB, 1991].

4. MODELING AND SIMULATION DEVELOPMENT

As Table E-1 shows, 12 (7 percent) of the 179 recommendations concern improvements in the design and development of models and simulations. Almost all of these recommendations concern the development of models and simulations used in the acquisition, test, and evaluation of other systems. These improvements include the following:

- Testing and user activities should quantify and document test requirements for environment simulators used in the test and evaluation of electronic systems [ASB, 1981];
- Requirements for the preparation and approval of test and evaluation master plans (TEMPs) should be enforced [GAO, 1983];
- TEMPs should state existing abilities and inabilities to assess a system's operational suitability and effectiveness [GAO, 1983];
- DoD-wide guidance should be developed on producing, validating, documenting, managing, maintaining, using, and reporting simulations of system effectiveness [GAO, 1987];
- A model deficiency analysis and prioritization should be conducted along with a technology forecast to design a research program in campaign modeling and analysis [ASB, 1988];
- Technology for developing models and simulations should be adopted as much as possible from elsewhere and developed only for Army-unique needs [ASB, 1991].

5. MANAGEMENT IMPROVEMENT

As Table E-1 shows, 45 (25 percent) of the 179 recommendations concern improvements in the way modeling and simulation activities are conducted, controlled, and used. These recommendations included the following:

- The Army should coordinate its efforts to develop integrated Force Composition models with those of the other Services [ASB, 1980];
- Review the extent to which military and civilian defense analysts are aware of the empirical validity of their models [GAO, 1980];
- Develop plans and recommendations that allow the Organization of the Joint Chiefs of Staff to serve as the Defense Establishment's principal analytic advisor on the phenomenology of combat [GAO, 1980];

- Review the Defense intelligence community to identify and solve problems preventing its adequate support of threat simulator development [GAO, 1983];
- Organizations responsible for validating training devices, simulations, methods, and practices should be adequately resourced and independently reviewed [ASB, 1985a];
- The Army should re-consider limits on data exchange with NATO allies [ASB, 1988];
- Provide peer review of Army models and model development [ASB, 1988];
- Use wargame training models to identify analysis issues, but not to perform analysis;
- Deputy Undersecretary of the Army for Operations Research should take a leadership position with J-8 regarding Army analysis [ASB, 1988];
- Vice Chief of Staff of the Army and Vice Chief of Naval Operations should form a joint analysis steering committee for campaign models and analysis [ASB, 1988];
- The Joint Analysis Steering Group should take the lead in fostering the development of joint inputs for submission to J-8 [ASB, 1988];
- Quality Army personnel should be made available for assignment to J-8 and the staffs of the Unified Commands [ASB, 1988];
- Deputy Undersecretary of the Army should ensure that the Army analysis community participates with J-8 in supporting the CINCs' needs [ASB, 1988];
- Establish an Army analysis improvement program using senior analysts as trainers [ASB, 1988];
- Select 5-10 studies annually for close personal participation and technical review [ASB, 1988];
- Maintain a small number of joint analysis teams doing continual analysis of airland campaign issues [ASB, 1988];
- TRADOC should establish a pro-active cell of analysts and operations/doctrine experts to perform continuous analysis of joint/combined tactics, operations, and doctrine [ASB, 1988];
- Models used in Army joint studies should be technically understood by multiple agencies with a direct audit trail to objective, measurable data [ASB, 1988];
- AMMO's mission should include execution of joint/combined modeling developments and coordinating this work with outside agencies [ASB, 1988];

- DARPA should host a semi-annual joint modeling research seminar [ASB, 1988];
- The Services should strengthen internal controls over simulator acquisition by segregating responsibilities for development, testing, and acceptance of threat simulators [GAO, 1988];
- Establish the requirements for long-term joint simulation and document them in JCS directives [DSB, 1988];
- The Assistant Secretary of Defense for Force Management and Personnel should participate in establishing policies and procedures for wargaming and similar activities [IG, 1989];
- Discontinue operations at the Joint Warfare Center, discontinue their funding, and transfer management oversight responsibilities to the Joint Staff [IG, 1989];
- The Naval War College should request a waiver from the Joint Staff to allow the development, testing, and analysis of operational war plans and contingency plans. If denied the War College should discontinue its support of testing and analysis of plans [IG, 1989];
- The DCNO, Naval Warfare, should stop constructing Sensitive Compartmented Information Facilities at Navy schools when wargaming activities are limited to education and training [IG, 1989];
- Further development of the Command Readiness Exercise System by the Air Force should be coordinated with other Service schools [IG, 1989];
- Requirements for the Command Readiness Exercise System should be made consistent with Joint Chiefs of Staff policy on distribution of war plans and contingency plans [IG, 1989];
- The Warrior Preparation Center should prepare an updated management plan specifying its objectives, operating procedures, and facilities requirements [IG, 1989];
- Discontinue the $40 million in funding required by the Warrior Preparation Center to expand its facilities, procure computer systems, and develop computer models [IG, 1989];
- Ensure that the Warrior Preparation Center includes U.S. Army, Europe, U.S. Naval Forces, Europe, and the U.S. Air Force Europe in its wargaming exercises [IG, 1989];
- Ensure that the U.S. Government is reimbursed by NATO nations that participate in wargaming exercises held at the Warrior Preparation Center [IG, 1989];

- Re-examine the role and implementation of Manprint during systems acquisition to ensure the appropriate use of engineering simulations to identify and reduce potentially excessive training burdens of new and modified equipment [ASB, 1989];
- Independent panels of experts should assess specific applications of modeling and simulation results on which acquisition decisions are based [DSB, 1989];
- Modify DoDI 5000.2 to require that DAB documentation address the applicability of models and simulation [DSB, 1989];
- Approve and implement the EXCIMS/DMSO management scheme. DARPA should remain the lead OSD actor in R&D but pass overall management to the DMSO [DSB, 1989];
- Establish policies to ensure full integration of military science with the acquisition of modeling and simulation including the education of military service personnel in modeling and simulation developments and applications [FM&P, 1990];
- The Army should review the current structure of the Electronic Battlefield program [ASB, 1991];
- The Army should forego OPTEMPO as well as other funds to finance the new modes of training [ASB, 1991].

6. COORDINATION

As Table E-1 shows, 20 (11 percent) of the 179 recommendations concern the coordination of modeling and simulation activities or resources under single management or in a single location. These coordination recommendations are a subset of the management improvements discussed above. They include the following:

- The Army should task a full-time organizational element to integrate and coordinate human issues policy development, research, analysis, and modeling activities [ASB, 1980];
- The Army should establish a center of excellence for human issues modeling [ASB, 1980];
- The Organization of the Joint Chiefs of Staff should establish an institutional focus to provide the Defense analytic community with (1) a senior advisor, (2) a corporate memory, (3) a technical forum, and (4) an information dissemination center [GAO, 1980];
- Create a private sector organization as a core work force for the development of long-term, professional quality in simulation techniques [DDR&E, 1982];

- Establish a joint-Service threat simulator and aerial target improvement program to identify, time phase, and prioritize DoD-wide test resource deficiencies [GAO, 1983];
- Support the Hermann model of a tri-Service training and simulation R&D center with close university relations [JDL, 1983];
- The Vice Chief, Army, and the Vice Chief, Air Force, should form a joint analysis steering group at the headquarters level [ASB, 1988];
- This joint analysis steering group should resolve disparities among existing joint models and consider the development of joint scenarios and data bases for analyses [ASB, 1988];
- Chief of Staff, Army, and Chief of Naval Operations agree to examine specific areas of mutual cooperation in planning [ASB, 1988];
- Deputy Undersecretary of the Army, Operations Research, should take the lead in ensuring Army's continuation of a strong liaison with J-8 [ASB, 1988];
- Deputy Undersecretary of the Army, Operations Research, should form a Department of the Army level group comprised of senior experienced professionals to structure and implement procedures for peer review of Army campaign models [ASB, 1988];
- The Secretary of Defense should ensure that appropriate DoD elements execute responsibility and authority for centrally managing simulator programs [GAO, 1988];
- The Secretary of Defense should assign to an appropriate DoD element the responsibility for monitoring the quality of simulators acquired and participating in the acquisition process [GAO, 1988];
- Create a shared library of automated, validated data descriptions for simulation use that are available DoD-wide [DSB, 1988];
- The Director, Joint Staff, should designate an office of primary responsibility within the Joint Staff to establish policies and procedures on wargaming, simulations, modeling, and exercises and clarify the responsibilities and relationships of DoD participants in joint wargaming [IG, 1989];
- The Undersecretary of Defense, Acquisition, should ensure refinement, maintenance, and availability of models, weapon and threat data descriptions, and simulation elements having DoD-wide utility [DSB, 1989];
- The Electronic Battlefield program should be funded at the Department of Army level with a single manager and a direct mandate from the Secretary of the Army [ASB, 1991];

- A single manager should be put in charge of the Electronic Battlefield [ASB, 1991];
- The Army should develop a process and discipline to ensure quality of data across the total spectrum of model use--this should be a prime task of the manager of the Electronic Battlefield [ASB, 1991].