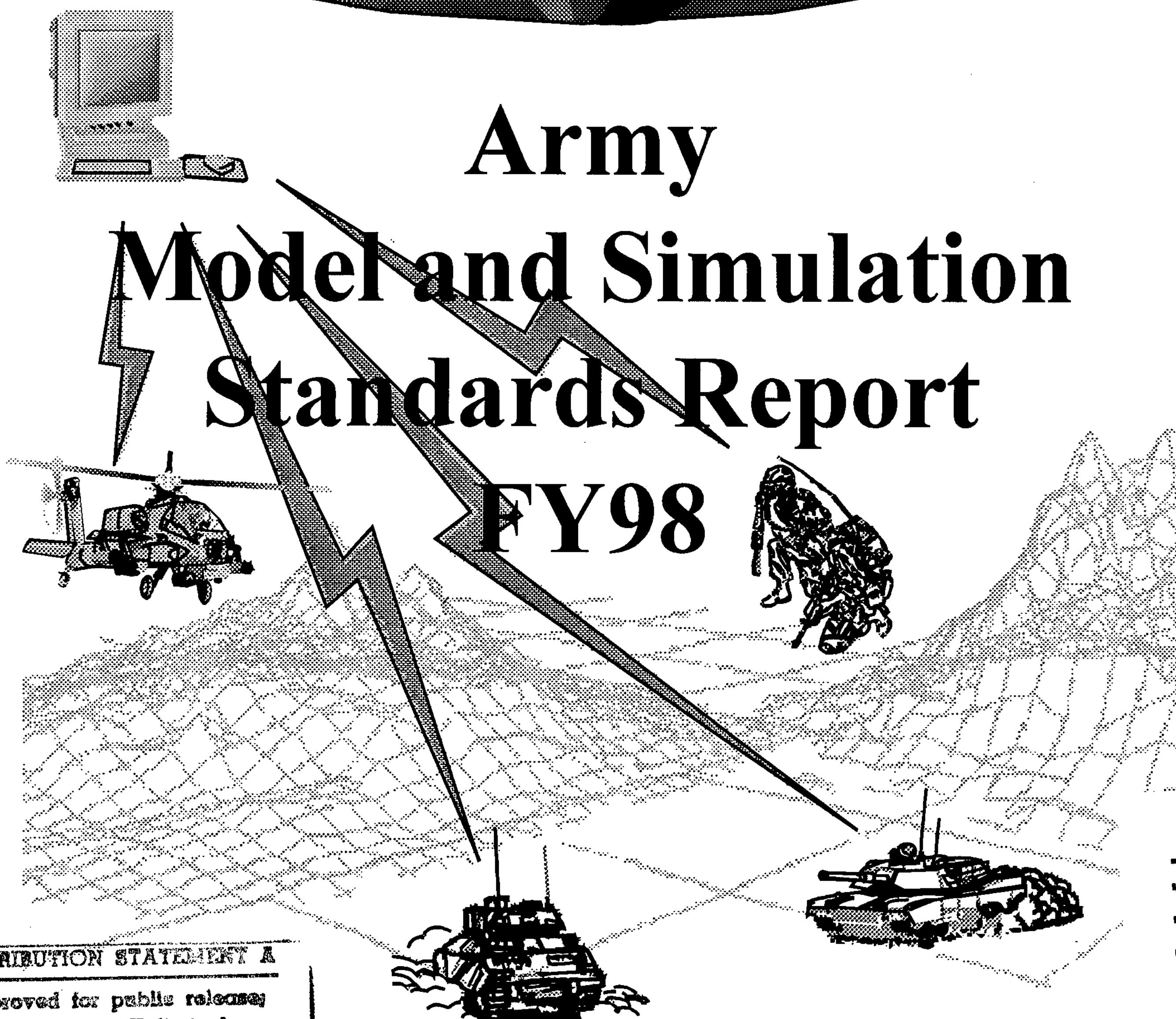
AMSO
Army Model and Simulation Office

# Army Model and Simulation Standards Report FY98



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# *Army Model and Simulation Standards Report FY98*

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The *Army Model and Simulation Standards Report FY 98* contains the status of Army efforts to standardize model and simulation techniques and procedures. It also reflects the Army's FY 98 model and simulation (M&S) investments through the Army Model Improvement Program (AMIP) and the Simulation Technology (SIMTECH) Program. These products are the result of efforts by dedicated and hard working professionals throughout the Army M&S community

The first Army M&S Standards Workshop sponsored by AMSO was held at the Army Center for Strategic Leadership, Carlisle Barracks, PA. This highly successful workshop served as a key opportunity for the identification, definition, exploration, and resolution of standards issues. Senior Army M&S leaders conveyed their standards requirements to the community. The Standards Category Coordinators and their team members found this forum vitally important to their efforts to establish meaningful standards.

These efforts on behalf of the Army are fully coordinated with and supportive of DoD initiatives with the same objectives of commonality and reuse. The Army Model and Simulation Master Plan, outlines the relationships between Army Standards Category Coordinators, DoD Executive Agents and the Architecture Management Group. I continue to expect each Standards Category Coordinator and team to be active, alert and in touch with the entire community in order to meet and support Army and DoD technological and reuse objectives.

The Army's vision for M&S describes the capabilities required for the future. The Army Model and Simulation Master Plan strategy for achieving the vision focuses on one fundamental objective, "World-class M&S that meet the needs of the Total Force." Standards development is a priority task in the main effort to accomplish this fundamental objective. The M&S community should commit itself to this task. As standards are developed and utilized in increasingly demanding environments, future problems will be reduced or eradicated, yielding a higher quality product which endures for years to come.

Our challenge is great and I invite all who have something to contribute to bring their ideas to the appropriate Standards Category Coordinator.

Walter W. Hollis
Deputy Under Secretary of the Army
(Operations Research)

# *Army Model and Simulation Standards Report FY98*

## SCOPE

This report provides information on the status and areas of interest concerning the FY98 investment in the Army Model Improvement Program and Simulation Technology Program (AMIP and SIMTECH). It represents a corporate Army investment program to develop model and simulation standards throughout the Army in 18 standards categories.

## PROPONENCY

The proponent for the *Army Model and Simulation Standards Report* is the Deputy Under Secretary of the Army for Operations Research, ATTN: SAUS-OR, The Pentagon, Army 102, Washington, DC 20310-0102. The functional manager is the Director, Army Model and Simulation Office, ATTN: DAMO-ZS, The Pentagon, Army 400, Washington, DC 20310-0450.

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## CHANGES

To help refine future revisions or republications, submit marked up copies to the functional manager.

## SPECIAL NOTES

This document is an official Department of the Army publication. It is provided for information purposes within the Department of the Army. It does not authorize procurement, nor does it legally or contractually bind the government for purchase of any goods or services.

## INTRODUCTION & PURPOSE

The FY98 Army Model and Simulation Standards Report provides a snapshot of Army Model and Simulation (M&S) standards efforts as work progresses towards the objective Army M&S environment. This report specifically documents projects approved for funding through the Army Model and Improvement Program (AMIP) and Simulation Technology Program (SIMTECH). It also provides background information on the standards categories, the organizations and individuals involved in the Standards Process.

Vital investments occur under both the AMIP and the SIMTECH programs. During July 1997, the Army Model and Simulation Office (AMSO) convened a meeting of the Army Model and Simulation Management Program Working Group (AMSMP WG) to evaluate and prioritize projects for FY98. The AMSEC reviewed the prioritized list of projects (Appendices D and E) and made recommendations to the DUSA(OR), the final approval authority for AMIP/SIMTECH funding.

Since the publication of last year's Standards Report, several changes were made to the Standards Category structure. For FY98, three new categories were added: 'Visualization', 'Object Management', and 'Functional Description of the Battlespace' (FDB). Based upon work at the Army M&S Standards Workshop, four categories were renamed to more accurately reflect their direction. Computer Generated Forces (CGF) was renamed to Semi-Automated Forces (SAF); Reasoning was renamed to Command Decision Modeling; Mobilization was renamed to Mobilization/Demobilization, and Command, Control, & Communications Systems to Control, Communications, & Computer Systems. Appendix B describes the current standards categories and their associated priorities for M&S work.

## SIMULATION TECHNOLOGY (SIMTECH) PROGRAM

The SIMTECH program complements the AMIP. Where the AMIP invests in technologies that are fairly well developed and have a high probability of returning value to the Army, SIMTECH invests in developing state-of-the-art M&S technologies. The SIMTECH program focuses on accelerating the development and transfer of emerging technologies to improve the art and science of M&S in all functional disciplines. Specific SIMTECH program goals are to:

1. Improve M&S development and modification techniques;
2. Ensure Army M&S more easily and accurately represent complex processes;
3. Develop less expensive technologies that maintain or improve Army M&S quality;
4. Develop techniques that increase M&S interoperability among and between M&S Domains; and
5. Provide state-of-the-art environments in Army commands and agencies that will attract and retain highly skilled personnel for M&S research and development.

One important SIMTECH program role is to transition SIMTECH developed applications, techniques and procedures to the AMIP, where they may be applied to critical near-term Army M&S needs. Additional project nomination guidance is in Appendix B of the Army M&S Master Plan.

## THE ARMY MODEL IMPROVEMENT PROGRAM (AMIP)

The AMIP provides funding to organizations to execute projects that support the achievement of standards category objectives. Each fiscal year, Standards Category Coordinators (SCCs) nominate M&S projects furthering objectives within their respective category. The project nominations are included as part of the Annual SCC's Report. The SCC and their team prioritize multiple nominations to indicate which projects address the most pressing standards requirements within that category. The nominations are integrated and prioritized by the Army Model and Simulation Management Program Working Group (AMSMP WG) and submitted through the Army Model and Simulation Executive Council (AMSEC) to the DUSA (OR) for approval Additional project nomination guidance is in Appendix B of the Army M&S Master Plan.

## M&S STANDARDS DEVELOPMENT PROCESS

The Army concept for M&S standards development is to use a process based on consensus. Many M&S technologies evolve at blinding speeds. Some technology niches turn over in a matter of months. Advances and lessons-learned take place within a myriad of organizations within the Army, Department of Defense (DoD), and throughout the world's commercial and academic sectors. The intent is to capture the intellectual energy and practical achievements of the entire M&S community to ensure that the standards the Army decides to adopt are affordable, relevant, and in keeping with the direction of the state-of-the-art and practice. By keeping the process consensus-based, those decisions are shaped by the hands of the real M&S experts.

By facilitating interoperability and reuse, M&S standards provide a basis for efficient development and application of M&S. By developing and promulgating standards, the Army M&S community shares expertise and lessons learned about techniques, procedures, processes, and applications. Standards development builds on the work of many people and organizations, and advances the art and science of M&S in tandem with technological advances.

Standards Development concentrates on the following areas: (1) Modeling of Army operations and physical phenomenology; (2) Modeling cognitive processes; (3) Standards for environmental representations; and (4) Development of guidelines and methods for assuring the quality and credibility of its M&S.

1. The modeling of Army operations and physical phenomenology is concerned with the creation of standard models or abstractions e.g., algorithms, structures, or taxonomy, of Army forces and their capabilities. These standards can describe several aspects of units: their physical characteristics, how they accomplish their missions, how they interact with other organizations and their environment, and how they function as part of a joint force. These standards should be system-independent abstractions of varying fidelity that support multiple simulation developments. They must be documented to support validation and to accommodate the evolution of the standards to represent the Army as it transitions to Army XXI.

2. Standards for modeling cognitive processes or the effects of cognitive processes on Army operations will make two major contributions to Army modeling and simulation. The first contribution is in the area of better models. Army operations are continuing to move away from stylized scenarios with a well-known, "by-the-book" threat into scenarios that emphasize information operations and the capabilities of people and organizations. Having reasonable models of the dynamics of human behavior under conditions of uncertainty will enable more credible representations of information operations yielding more robust analysis. Just as important, as digitization expands throughout the force, requirements continue to growing for simulation systems to provide more detail about simulated forces while, at the same time, requiring fewer operators. Standards for cognitive process that enable the development of realistic semi-automated forces will be crucial for conserving resources.

3. There are three DoD Executive Agents to develop standards for environmental representations: (1) Terrain; (2) Oceans; and (3) Atmosphere. The Army must work to help the DoD Executive Agents formulate and shape their standards so that they meet Army requirements. This is an important area for ensuring the commonality or at least consistency between Army and other Services' M&S.

4. DoD has invested significant resources in the development of guidelines and methods for assuring the quality and credibility of its M&S. Verification, Validation, and Accreditation (VV&A) is the fundamental process by which credible M&S development is obtained. The Army is a leader in developing VV&A techniques and must continue to strive to maintain this lead as M&S becomes more complex and encompassing. The Army also recognizes that with Cost As an Independent Variable (CAIV) for development, there must be some consideration for how much credibility is enough to support the mission. As the technology and the standards processes mature, the procedures for ensuring credibility must be updated to remain relevant.

## Types Of Standards

The term standard is applied in the broadest context to include procedures, practices, processes, techniques and algorithms. Standards for M&S cover a variety of topics and the type and source of relevant standards will vary with each standards category. There are standards for simulations such as HLA. Several types of standards for data apply: meta-data, data structures, raw data, and data storage and transmission. Standards also exist for the process associated with the development and use of M&S. Examples are standards for building simulation object models, federation object models, and conducting Verification, Validation and Accreditation (VV&A). Standards are developed internally within the Army M&S community and are adopted from other disciplines and organizations.

## Levels Of M&S Standards

As adopted in the FY 97 Army M&S Master Plan, there are three levels of standards: Draft Standards, Approved Standards, and Mandatory Standards. The different levels indicate the degree of maturity of the standard and the level of enforcement. The goal is to develop standards that are value-added to the consumer.

### Draft Standards

Draft standards are the initial level standards. These standards have not completed the review process but are available to the community for use as best meets their program goals pending further maturation to a higher level.

### Approved Standards

DUSA (OR)-approved standards are the next higher-level. These standards have been reviewed and demonstrated sufficient maturity and consensus to warrant their recommendation to the DUSA (OR) for approval. The intent is to designate standards that facilitate interoperability, reuse, and efficiency that developers can adopt to reduce their development, VV&A, and operational costs.

### Mandatory Standards

Mandatory Standards are the highest-level standards and are promulgated by regulation or policy statement. Developers and users of Army M&S systems must follow these standards. While some may raise short-term costs for individual programs, the value in adopting standards is their overall and long-term benefit to the Army.

## Categories of Standards

Standards categories are approved by the DUSA (OR). The intent is to have sufficient standards categories to cover the realm of technologies and processes important to M&S development and use within the Army. The AMSMP WG may recommend changes concerning the categories to reflect advances in technology and changes in the management of technology within DoD and the Army. Definitions for each category are in Appendix B.

The goal of the standards development process is to support all Army M&S Domains. The three Domains are: Advanced Concepts and Requirements (ACR); Research, Development, and Acquisition (RDA); and Training, Exercises, and Military Operations (TEMO). Figure 1 depicts how the 18 categories support both the DOD objectives and the Army M&S Domains and their requirements for standards.

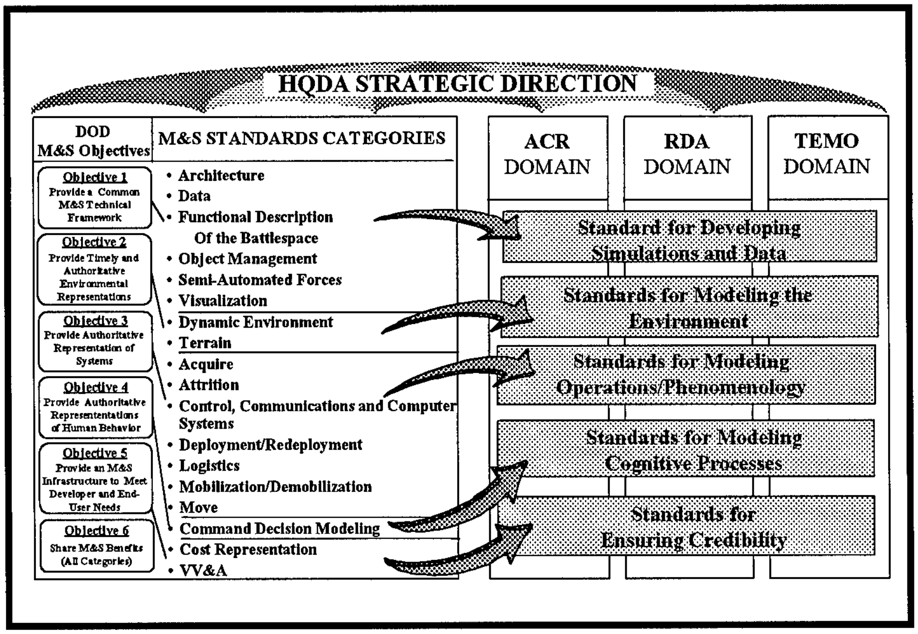


**Figure 1. HQDA Strategic Direction**

## Standards Category Coordinators (SCCs)

Once a standards category is approved, individual Major Army Commands (MACOMs), Field Operating Agencies (FOAs), or Staff Support Agencies (SSAs) can request to be responsible for the category. The DUSA (OR) approves the designation and that organization then appoints the SCC from within.. The SCCs are normally drawn from a center of technical or procedural excellence and have gained the respect of the community for their knowledge, experience, and contributions to Army M&S. Specific SCC responsibilities include executing the Standards Development Process for the category, publishing the SCC Annual Report, and supporting the AMIP. Appendix A contains the identification and contact information for each SCC.

## The Process

As a result of the Directors' meeting at the Army M&S Standards Workshop held in May, a decision was made to include a more formal review and approval process in the Standards Development Process. The "Define Requirements" step now includes a discreet initiation with the submission of a Standards Requirement Document (SRD) that defines the need. In addition to the methods previously used, consensus will be obtained through discussions via e-mail reflectors. A new step, "Obtain Approval," was added to formalize the Senior level review of the standard prior to final approval by the DUSA(OR).

Standards development occurs within the seven step process depicted below. Beginning at the bottom left of Figure 2, once an SCC is appointed and begins building a team, the process is continuous, with SCCs conscientiously employing a variety of media and techniques to advance toward their defined requirements through the following steps.

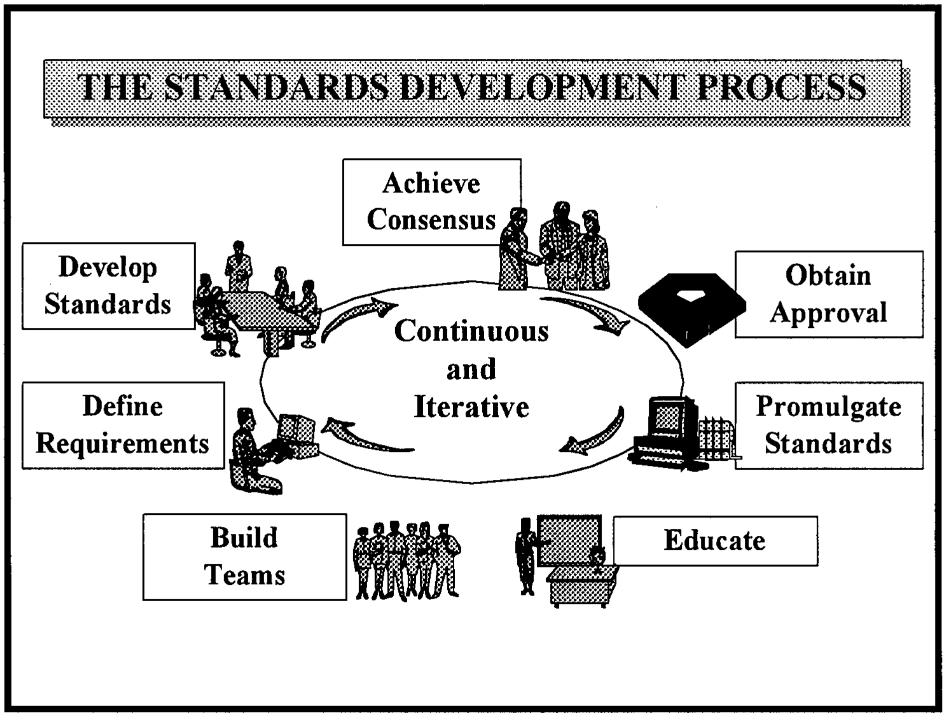


**Figure 2. Standards Development Process**

### Step 1: Build Team

Pulling together experts from within a particular M&S discipline to form a Standards Category Team is the first and most critical step in the Standards Development Process. These experts can come from the Army, DoD, academia, and private industry. The team should provide the SCC with a wide range of expertise and means to keep abreast of developments relevant to the standards category. Team membership is not static. As new issues develop or old ones are resolved, the team membership may change to address current issues. Individuals may join a team at any time; membership is based on the concept of inclusion rather than exclusion. Forums that advance the teaming process include: conferences, workshops, publications, and communications that promote the exchange of ideas, techniques and procedures. To facilitate the teaming process and assist in identifying community requirements, AMSO established e-mail reflectors for each of the Standards Categories. The address to subscribe is **http://apps.sc.ist.ucf.edu/listproc/index.cfm?client=AMSO**. You can either go there directly or link there through the AMSO homepage. Appendix A contains a complete listing of the reflectors.

### Step 2: Define Requirements

The SCC and team define the scope of their category. The definitions for each category are reviewed by the AMSMP WG and then recommended to the DUSA (OR) for approval. Given the definition for the category, the team then sets standards priorities for the next five years based on the potential benefit to the Army M&S community, the maturity of the standards area, and the probability of success. Building from these long-term goals, the team identifies potential areas for standards development and establishes requirements for each area which are reviewed and validated by AMSO. Appendix B contains the current definition and requirements for each category. The SRD will be the basis for documenting the need for a standard. The SRD is still under development. Additional information will be available at the AMSO homepage.

**Step 3: Develop Standards**

Developing and identifying standards is the crux of the process. Standards may be of many types e.g., procedures, practices, processes, algorithms, or techniques. The wider the involvement of experts across the M&S community, the more likely each category will capture particulars worthy of being standards. Standards are not limited to those specifically developed by the team. They may include "best and current practices" or products that the team feels warrant being considered as standards for Army M&S.

**Step 4: Achieve Consensus**

Since the process is based on consensus, the SCC and team must achieve consensus within the M&S Domains and the community on a proposed standard prior to its being recommended to the DUSA (OR) for approval. In addition to developing and identifying standards, the team members assist the SCC in achieving consensus on the proposed standards. The e-mail reflectors will be a key tool to achieve consensus.

**Step 5: Obtain Approval**

Once consensus has been achieved for a standard, review and balloting is done by Army Senior Analysts. It is then submitted to the DUSA (OR) for approval or denial as an Army M&S Standard. Further details on the Senior level review and balloting will be available on the AMSO homepage.

**Step 6: Promulgate Standards**

The SCC can use a variety of methods to ensure the widest dissemination, availability, and use consistent with Army policies. SCCs have established e-mail reflectors to facilitate standards discussion and the notification process. This year an AMIP project submitted by the FDB category will develop the capability to make these standards available via the internet through standard repositories. Other methods to disseminate the information include building document libraries and electronic repositories to make available common use models, objects, algorithms, software, and data.

**Step 7: Educate**

Once a standard has been established and promulgated at a certain level (e.g. Draft,Approved, Mandatory), the SCC and team begin educating the M&S community on the availability, applicability, and use of the standard. They assist M&S developers and users as they build and use applications and educate leaders and decision makers on the benefits of the standard.

### The Army M&S Standards Workshop

The annual AMSO-sponsored M&S Standards workshop for SCCs and their teams serves as a key opportunity for the identification, definition, exploration, and resolution of standards issues. It is important to develop standards in a timely manner to support major simulation acquisition programs and minimize the use of proprietary or contractor-unique approaches. It is equally important to identify and adopt products from major simulation programs for incorporation in future M&S. At the workshop, each category team updates their category Roadmap and evaluates draft AMIP projects according to their Roadmap.

This process involves serious thought and insight into the needs and requirements for current and future Army M&S. New issues and topics requiring attention and discussion are uncovered. The workshop format allows team members from different categories to interact and determine the best way to cover new issues as well as strengthen current topics.

At the conclusion of the workshop, the SCCs provide a briefing that highlights their standards development efforts e.g., their Roadmaps, updated definitions and requirements, and draft AMIP project nominations. This allows the attendees an opportunity to comment on the project nominations. Based on feedback from the audience, comprised of the AMSMP WG, other SCCs, and team members, the SCCs will be able to incorporate useful information into their project nominations.

The workshop for FY98 will be held at the Army Center for Strategic Leadership, Carlisle Barracks, PA from 4-7 May. Updated information concerning the workshop will be posted at the AMSO homepage.

# APPENDIX A

## Key Personnel and Information

## STANDARDS CATEGORY COORDINATORS

| CATEGORY | NAME | ADDRESS | PHONE | E-MAIL |
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| **Acquire** | Dave Dixon | TRADOC Analysis Center - WSMRATTN: ATRC-WB (Mr. Dixon)<br>White Sands Missile Range, NM 88002-5502 | V: (505) 678-4510<br>DSN: 258-4510<br>F: (505) 678-5104 | dixond@trac.wsmr.army.mil |
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| **Attrition** | Alan Dinsmore | Director, AMSAA<br>ATTN: AMXSY-CD (Mr. Alan Dinsmore)<br>392 Hopkins Road<br>Aberdeen Proving Ground, MD 21005 5071 | V: (401) 278-2785<br>DSN: 298-2785<br>F: (401) 278-6585 | adin@arl.mil |
| **Command Decision Modeling** | Sean MacKinnon | National Simulation Center<br>ATTN: ATZL-NSC-D<br>Fort Leavenworth, KS 66027-2345 | (913) 684-8290<br>DSN: 552-8290<br>F (913) 684-8302 | mackinns@leav-emh.army.mil |
| **Control, Communications and Computer Systems Representation** | Burt Kunkel | Modeling & Simulation Branch<br>Concepts and Architecture Division<br>Directorate of Combat Developments<br>Ft. Gordon Ga. 30905-5090 | (706) 791-1977<br>DSN: 780-1977<br>F (706) 791-6595 | kunkelb@emh1.gordon.army.mil |
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## STANDARDS CATEGORY COORDINATORS

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| **Logistics** | Ron Fischer | USA CASCOM<br>ATTN: ATCL-Q<br>Fort Lee, VA 23801-6000 | V: (804) 765-0683<br>DSN: 539-0683<br>F: (804) 765-4993 | fischerr@lee-emh2.army.mil |
| **Mobilization** | Julie Allison | Director, USA CAA<br>ATTN: CSCA-0S (Ms. Julie Allison)<br>8120 Woodmont Ave.<br>Bethesda, MD 20814-2797 | (301) 295-1588<br>DSN 295-1588<br>F (301) 295-5110 | allisonj@caa.army.mil |
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## STANDARDS CATEGORY COORDINATORS

| CATEGORY | NAME | ADDRESS | PHONE | E-MAIL |
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| **VV&A** | Larry Cantwell | TRADOC Analysis Center<br>ATTN: ATRC-FZ<br>255 Sedgewick Ave. BLDG. 314<br>Fort Leavenworth, KS 66027-2345 | V: (913) 684-6867<br>DSN: 552-6867<br>F: (913) 684-9151 | cantwell@trac.army.mil |
| *Questions or Issues related to the Standards Process, AMIP, and the SCCs can be directed to the following:* | | | | |
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| Acquire | Dave Dixon | amso-scc-acquire@sc.ist.ucf.edu |
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| Administrative | MAJ Stephen Johnson | amso-scc-admin@sc.ist.ucf.edu |

*Appendix A*

## ARMY MODEL AND SIMULATION MANAGEMENT PROGRAM WORKING GROUP

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# ARMY MODEL AND SIMULATION MANAGEMENT PROGRAM WORKING GROUP

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# APPENDIX B

## Standards Category Definitions and Requirements

## STANDARDS CATEGORY DEFINITIONS AND REQUIREMENTS

| Categories | Definitions | Requirements |
|---|---|---|
| **Acquire** | Encompasses those algorithms which model the phenomena pertaining to the firsthand collection of battlefield information by an observer/sensor. In general four quantities or processes are addressed in this Standard Category: (1) Signatures of the battlefield environment, including signatures of both the datum of interest and the surrounding environment; (2) Signature transmission/transformation from source to receptor; (3) Discrimination of target/datum of interest from background; and (4) The search process performed in the examination of the battlefield. Applicable to signatures in the acoustic and electromagnetic (ultraviolet, visible, infrared, and radar) spectra with either reflective or emissive sources. Countermeasures to acquisition (signature reduction, reduced signature transmission, or degraded discrimination capability) are also applicable.. | • Developing target and background signature models to generate data needed for combat simulations and models<br>• Conducting discrimination and search research, and developing standard representations for use in combat models and simulations<br>• Developing standard techniques for implementing environmental and acquisition perception models into combat models and simulations |
| **Architecture** | The structure of components in a program/system, their relationships and principles and guidelines governing their design and evolution over time. Architecture includes the system framework and components that facilitate interoperability of all types of models and simulations, as well as facilitate reuse of M&S components. It encompasses virtual, constructive, and live simulations from ACR, RDA and TEMO domains. | • Develop, demonstrate, and promote common components, standards, protocols, interfaces, processes and methodologies<br>• Transition current standardization efforts and all new standards development efforts to be in compliance with the emerging joint technical architecture and specifically the DoD M&S High Level Architecture<br>• Develop an awareness of evolving architectures, including, but not limited to Virtual Reality Machine Language (VRML) and the Dismounted Warrior Network (DWN) |
| **Attrition** | Addresses the algorithms and processes that encompass the selection, prioritization and engagement of targets and the subsequent battle damage assessment and disengagement of combatant forces. Also included within this framework are physical processes that represent the probabilities of hit/kill for both direct and indirect fire weapon systems, effects of countermeasures, tracking and designation of targets, flyout of projectiles (including line-of-sight checks as appropriate), ammunition expenditure, and battle damage assessment. | • Establish standard attrition methodologies.<br>• Facilitate use of standard attrition methodologies by the M&S community<br>• Improve known weaknesses<br>• Investigate the adequacy of current methodologies and replace where deficient |
| **Command Decision Modeling** | Algorithms that model or simulate human behavior that results in an action taken, a decision or reaction being made or a plan being formed. | • Advance the art of modeling decision making processes for SAFOR, CGF and constructive simulations<br>• Develop a planning process standard<br>• Develop a battle management language standard<br>• Develop a framework for representing command knowledge |
| **Control,** | Encompasses the objects, algorithms and techniques necessary to | • Define and design objective systems M&S representations |

## STANDARDS CATEGORY DEFINITIONS AND REQUIREMENTS

| Categories | Definitions | Requirements |
|---|---|---|
| **Communications and Computer Systems Representation** | replicate friendly and enemy control, communications and computer systems and processes. | • Coordinate common systems representations with other categories<br>• Upgrade current M&S capabilities to replicate systems<br>• Insure design will permit systems interface with other M&S in the constructive and virtual worlds<br>• Insure HLA compliance is part of the development of new M&S communications models<br>• Provide for data interchange of allow communications effects to play in combat models<br>• Develop MOE's to identify key elements and validation tolerances for control, communications, and computer M&S<br>• Insure the models are available to users |
| **Cost Representation** | Includes the data, tools, algorithms and techniques necessary for accurately costing and consistently portraying all aspects of activities portrayed in models and simulations. | • Develop methods to cost all elements portrayed in M&S<br>• Standardize techniques for comparing costs of alternatives |
| **Data** | Procedures that increase information sharing effectiveness by establishing standardization of data elements, data base construction, accessibility procedures, data maintenance and control. | • Promote Data Standards<br>• Develop infrastructure<br>⇒ Data modeling tools and training<br>⇒ Standardize data structures<br>• Automate existing databases<br>• Develop new databases<br>• Expand Education |
| **Deployment/ Redeployment** | Includes the objects, algorithms, data and processes needed to accurately portray the relocation of military and civilian forces from the origin to the area of operations, and the preparation for and movement of forces from one are of operations to follow-on designated CONUS or OCONUS bases or areas of operation. | • Develop modeling standards that address all deployment domains (e.g. ACR, TEMO, RD&A, execution, planning, analysis, training,) and all the joint end-to-end process element<br>• Develop a common object structure for the representation of all aspects of deployment/transportation, including forces (equipment, personnel, and supplies), transportation assets, cargo, and infrastructure<br>• Develop and document deployment related objects, entities, actions, algorithms, and processes at various levels of resolution<br>• Ensure commonality and linkages with mobilization, logistics, and warfight simulations |
| **Dynamic Environment** | Includes the objects, algorithms, data and techniques required to replicate weather, weather effects, background changes due to environmental effects, effects on acoustic propagation, and transport and diffusion of aerosols as battle by-products in models and simulations. | • Provide fundamental environmental data for M&S<br>• Provide consistent data for environmental effects models<br>• Provide standardized database for system performance analysis<br>• Provide set of standard synthetic natural environments |

## STANDARDS CATEGORY DEFINITIONS AND REQUIREMENTS

| Categories | Definitions | Requirements |
|---|---|---|
| **Functional Description of the Battlespace** | The process that develops simulation and research database configuration and management tools consistent in their representation of Army Battlespace Domain activities and functions, understood by the M&S community, and interoperable at levels allowed by their model environment. | • Development of definitions of simulation development methods for Army use<br>• Development of policy and procedures for managing Army repository data, models, and algorithms for the simulation developers and users<br>• Form liaison relationships between major Army simulation programs and other Standard Categories to encourage use, updates, and expansion of object classes; and<br>• Explore methods of gathering, sharing and storing database models, data and algorithms for building new models, conducting new processes and establishing standards for reuse on future development programs |
| **Logistics** | Objects, algorithms, data and processes which model or simulate the initial provisioning, supply, resupply, stockage,. facilities, maintenance and sparing of the ten classes of supply and CSS services provided to and in the field. Army standardization requirements must address M&S support for CSS functions to and in the field | Develop standards to support M&S for the following Combat Service Support functions (in priority order):<br>1. Class III (Bulk POL)<br>2. Class V (Ammo)<br>3. Class VII (Major End Items)<br>4. Class IX (Repair Parts)<br>5. Personnel<br>6. Class I (Food and water)<br>7. Maintenance<br>8. Medical<br>9. Services<br>10. Classes II (Gen. Supplies), III (Pkg) POL), and IV (Construction Material)<br>11. Finance<br>12. Stockage<br>13. Classes VI (Personal Demand) and X<br>14. Facilities |
| **Mobilization/ Demobilization** | Includes the algorithms, objects and unique modeling techniques needed to accurately portray preparation of forces for military operations and their return, to include: active units, reserve units, active duty individuals, mobilization of Reserve Component (RC) individuals, expansion of CONUS/OCONUS installation support facilities, preparation for overseas movement, and surge and expansion of the industrial base. | • Standardize algorithms, objects and techniques for modeling mobilization<br>• Provide linkage of mobilization models and simulations to real time data bases<br>• Create HLA federation with strategic deployment and transportation modeling objects and algorithms. |
| **Move** | Encompasses the objects, algorithms, data and techniques necessary to replicate activities that influence land force platform and personnel movement (ground, air, and water). It also addresses mobility and countermobility as engineer functions, suppression (as a mobility degrader), formations, and dispersion. | • Land force platform and personnel movement<br>• Mobility and countermobility as engineer functions<br>• Suppression effects on movement<br>• Dispersion and formations |
| **Object Management** | The process that develops abstract object classes that are: (1) consistent in their representation of object attributes/methods; (2) understood by the M&S community; and (3) interoperable at levels allowed by their model environment. | • Develop definitions of abstract object classes for Army use<br>• Develop policy and procedures for managing Army objects<br>• Form liaisons between major Army simulation programs<br>• Explore methods for gathering, sharing and storing meta data about objects |
| **Semi-Automated** | Software integration which produces realistic entities in | • Develop SAF standards that are useful in all M&S domains, applicable to |

# STANDARDS CATEGORY DEFINITIONS AND REQUIREMENTS

| Categories | Definitions | Requirements |
|---|---|---|
| **Forces (SAF)** | synthetic environments which interface appropriately with live, constructive, virtual and simulator entities, but which are generated , controlled and directed by computer routines. | distributed simulations, representative from single entity to corps, and useful in a joint environment<br>• Minimize operator overhead for SAF<br>• Ensure structures and data bases are modular and easily isolated<br>• Provide consistent representations for battle field systems, and unit tactical/doctrinal behaviors in all SAFs<br>• Support the development of the High Level Architecture |
| **Terrain** | Includes the objects, algorithms, data, and techniques required to represent terrain and dynamic terrain processes in modeling and simulation. | • Defining digital terrain data content, resolution and accuracy requirements for developmental models and simulations<br>• Developing correlated terrain databases<br>• Developing techniques for rapid terrain database generation<br>• Developing techniques for dynamic terrain features<br>• Developing a consensus based data exchange standard<br>• Developing reuse repositories |
| **Verification, Validation & Accreditation (VV&A)** | Verification is the process of determining if the M&S accurately represent the developer's conceptual description and specifications and meets the needs stated in the requirements document. Validation is the process of determining the extent to which the M&S adequately represents the real-world from the perspective of its intended use. This process ranges from single modules to the entire system. Accreditation is an official determination that the M&S are acceptable for its intended purpose. | • Establish and define standard verification, validation, and accreditation processes<br>• Build verification and validation tools and guidelines<br>• Make the above tools available to users<br>• Develop measures of effectiveness to identify key elements and establish validation tolerances |
| **Visualization** | The process that develops hardware, software and procedural standards to provide a seamless vision of the battlespace by incorporating and integrating the environment, entities and their psychologies across virtual, constructive and live simulations. This enables leaders, decision-makers, staffs and soldiers at all levels to attain cognitive awareness of the battlespace. | • Determine how Visualization relates to the other standards categories and to C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaisance)<br>• Define and articulate attainable, adaptable, and scaleable standards<br>• Implement standards |

## APPENDIX C

## Standard Category Coordinators' Annual Reports

**Categories** **Page**

**Annual Standards Category Report for FY98**

**ACQUIRE**

## STANDARDS CATEGORY DEFINITION

The Acquire Standard Category encompasses those algorithms which model the phenomena pertaining to the firsthand collection of battlefield information by an observer/sensor. In general four quantities or processes are addressed in this Standard Category:

1. Signatures of the battlefield environment, including signatures of both the datum of interest and the surrounding environment.
2. Signature transmission/transformation from source to receptor.
3. Discrimination of target/datum of interest from background.
4. The search process performed in the examination of the battlefield.

The Acquire Standard Category is applicable to signatures in the acoustic and electromagnetic (ultraviolet, visible, infrared, and radar) spectra with either reflective or emissive sources. Countermeasures to acquisition (signature reduction, reduced signature transmission, or degraded discrimination capability) are also applicable.

## STANDARDS REQUIREMENTS

This standards category involves objects, algorithms, data and techniques which represent battlefield information collection. Standardization objectives include:

1. Developing target and background signature models to generate data needed for combat simulations and models.
2. Conducting discrimination and search research, and developing standard representations for use in combat models and simulations.
3. Developing standard techniques for implementing environmental and acquisition perception models into combat models and simulations.

The crucial areas for acquisition model development fall in the areas pertaining to human-in-the-loop acquisition performance. Both the constructive simulation and virtual simulation environments have acquisition performance data and algorithms in common, therefore work on these topics has wide application and a corresponding high return on investment.

## ACCOMPLISHMENTS AND ASSESSMENT

1. The FY96 project <u>Integrated Dynamic Multispectral Tactical Engagement Ground Targets, Backgrounds and Interaction for AMIP</u> has completed the work funded in 1996. This project was partially funded at $42K, down from $70K. The project has completed selection of the various computational models necessary to create high-resolution, high-fidelity thermal images and produce Computer Simulation Graphics (CSG) models with integrated thermal information. In the period since the project was first proposed and funded the emphasis for the Standard Category has shifted to standards development, therefore the remaining activities for this project have been proposed for transition to a SIMTECH project. The DELPHI project started last year is on schedule for its first phase (FY97). This is a two-year project to extract and calibrate to US acquisition criteria, the nonproprietary visual target acquisition algorithms of the BAE ORACLE

vision model. In the first nine months, nonproprietary algorithms which duplicate the performance of the original ORACLE of the cone midget channel (stationary target) algorithms have been identified. Also several data sets have been identified for the calibration process. These data sources include stationary and moving targets; unaided eye and magnified optics; field-of-view and field-of-regard search; high and low light levels; and target detection, recognition, and identification. The next step is to develop a nonproprietary version of the cone diffuse (moving target) algorithms and to calibrate both channels (midget and diffuse) with the identified data sets. The final product will be a standard model for visual target acquisition.

2. Draft standard algorithms for visual target contrast propagation and for perception misidentification are in work but not ready for inclusion in this report. The draft standard for visual target contrast propagation is expected to be completed by the end of FY 97 and the misidentification standard algorithm in the third quarter FY98.

**PRIORITIES FOR FUTURE WORK**

The prioritization of research and development submissions in the Acquire category is focused on the identification and development of an initial set of standards. The prioritization of other work in the category remains the same as previous years with human acquisition performance modeling as the focus. Priorities for submissions for FY98 have been assigned based on the following rationales:

A. Projects developing standard models of the search and target acquisition processes for inclusion in the initial set of ACQUIRE standards should be given first priority for funding. An initial set of standards for the four basic acquisition processes will help promote uniform and efficient implementation of search and target acquisition algorithms across Army M&S.

B. Research and development projects for target acquisition models for acoustic and radar sensors to fill identified voids in the initial set of ACQUIRE standards.

C. Third priority for funding should fall to discrimination and search modeling research, these are the least robustly modeled topics in the ACQUIRE category. The current soft state of modeling in these areas has implication for the utility and fidelity of engineering, constructive, and virtual simulations.

D. Forth priority for funding should apply research into to target, background signature and environment and propagation modeling, the current state of the art is as robust as the signature area however the level of the immediate return on investment is lower.

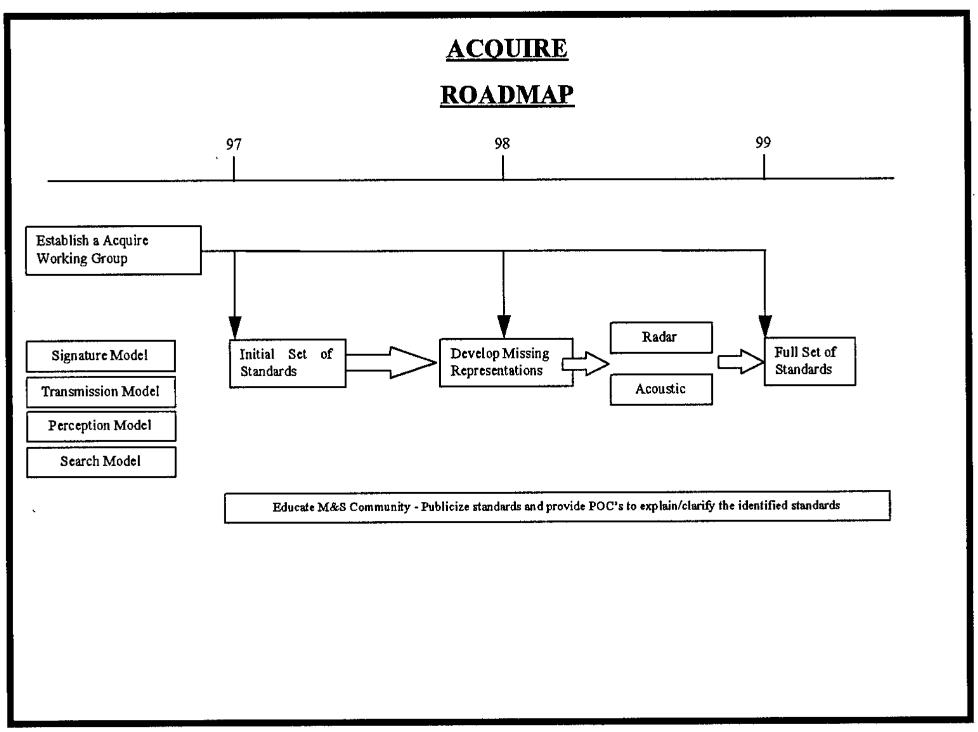
Based on these criteria Standard Category Acquire is submitting two proposals, the first proposal to continue the development of the Delphi vision model for use as the standard model for optical sensor target acquisition in combat simulations. The second proposal is a new proposal taking an existing NVESD contrast model that can compute the contrast of a target against a specified background and complete the verification of the model, expand the model's surface materials database with existing data acquired since the models development, and expand and complete the model' documentation ; the detailed proposals are contained in appendixes A and B.

## ROAD MAP

The road map for ACQUIRE remains largely unchanged:

1. The initial set of standards for optical and electro-optic (EO) sensors is about 65% complete. With the addition of a misidentification algorithm for EO sensors , initial standards for EO sensors for each of the ACQUIRE processes will be complete. The completion of the DELPHI vision model project, the optical contrast model project and a misidentification algorithm for optical sensors will complete a set of initial standard algorithms for optical sensors for each of the ACQUIRE processes.
2. The next phase of standards development, the initial standards for acoustic and radar work is just beginning. The work will require the identification or development of suitable models representing the ACQUIRE processes for acoustic and radar sensors and the preparation of standards for each model. The assessment of the status of modeling in these areas is a focus area for the working group during FY 98.

The issue of HLA compliance is being explored, some of the ACQUIRE standards can easily be implemented as algorithms, some standards exist as standalone data generators for ACQUIRE processes, some however exist as simulations that may appropriately become part of an HLA federation. This issue is under examination at this time by the working group, it is expected that as the Army's HLA posture matures, the effectiveness of HLA compliance for some ACQUIRE standards will become clear.



*Acquire*

## Annual Standards Category Report for FY98

## ARCHITECTURE

This report provides a status of architecture standardization efforts, including identification of significant progress made during the past year and standardization priorities for FY98.

### STANDARDS CATEGORY DEFINITION

The following definition of Architecture, from the DoD Modeling and Simulation Master Plan, is proposed:

"Architecture is the structure of components in a program/system, their interrelationships, and principles and guidelines governing their design and evolution over time." Architecture includes the system framework and components that facilitate interoperability of all types of models and simulations, as well as facilitate reuse of M&S components. It encompasses virtual, constructive, and live simulations from the Advanced Concepts and Requirements (ACR), Research, Development and Acquisition (RDA), and Training, Exercise and Military Operations (TEMO) domains.

### STANDARDS REQUIREMENTS

The proposed Army standardization requirements for architecture are:

1. Develop, demonstrate, and promote common components, standards, protocols, interfaces, processes and methodologies.
2. Transition current standardization efforts and all new standards development efforts to be in compliance with the emerging joint technical architecture and specifically the DoD M&S High Level Architecture.
3. Develop an awareness of evolving architectures, including, but not limited to Virtual Reality Machine Language (VRML) and the Dismounted Warrior Network (DWN).

### ACCOMPLISHMENTS AND ASSESSMENT

For each of the architecture standardization requirements the following accomplishments were made during FY97. The assessment of these projects is that the Army and DoD are adequately funding technology related to architecture so that standards can be developed.

1. **Development, demonstration, and promotion of common components, standards, protocols, interfaces, processes and methodologies.**

- IEEE Standards Activity. In the Army's continuing effort to gain IEEE acceptance of DIS Standards, IEEE 1278.3, titled "Exercise Management & Feedback", was submitted for approval in November 1996. IEEE 1278.4, titled "Recommended Practice for Distributed Interactive Simulation (DIS)", was balloted in December 1996. Both are approved for use during the transition to the HLA.
- SISO. The Simulation Interoperability Standards Organization (SISO), which evolved from the DIS Standards organization, has made a commitment to develop standards that apply across multiple classes of simulations by incorporating the HLA and affiliated standards, and

hence to support the full range of DoD simulation needs. DIS is a government/industry initiative to define standards for linking various elements of the simulation domain. To date, DIS standards have been applicable to the class of virtual simulation. The HLA will apply to the full range of simulations.

- SIW. The March 1997 Simulation Interoperability Workshop (SIW) marked the official kickoff of the new standards workshops. The SIW supports the entire Modeling and Simulation (M&S) community by embracing the DoD High Level Architecture (HLA). Historically, the workshop evolved from the DIS Workshop; however, the scope of the workshop has been changed to encompass a broader range of simulation issues and communities, including DoD as well as other government and non-government applications. Participants include simulation developers, simulation users, and operations analysts, from various government, industry, and academic communities. Attendance at the Spring 1997 Workshop exceeded 1200, and it is expected that participation will increase at the Fall 1997 SIW.

- RTI. DMSO is sponsoring the Runtime Infrastructure (RTI) software development during the HLA transition period in an effort to ensure the technical feasibility of development of RTI software, to provide a common use implementation which is freely available across the DoD and industry, and to provide a base for HLA technical experimentation. The development will be accomplished in two phases. RTI 1.0 is a government-developed initial RTI build. RTI 2.0 will be developed by industry, based on a open competitive design process.

2. Transition current standards efforts and all new standards development efforts to be in compliance with the emerging joint technical architecture and specifically the DoD High Level Architecture (HLA).

- HLA Baseline. The HLA baseline definition was developed through a set of prototypes which implemented a diverse set of applications using earlier HLA specifications. The experience of these prototypes was used to evolve the specifications which established the current HLA baseline. The technical reports from these efforts are available on the DMSO home page (www.dmso.mil).

- JTA Appendix G. The Joint Technical Architecture (JTA) standard has been revised to include an appendix specifically directed towards the M&S community. Appendix G includes those standards applicable to the M&S community, such as information processing standards and data exchange standards. More information can be found on the JTA home page (www.itsi.disa.mil/jta).

- SISO Information Processing Standards. Two standards nominations have been submitted to the Standards Activity Committee (SAC), which is an organization under the Simulation Interoperability Standards Organization (SISO). The HLA standards nomination includes the HLA Interface Specification, the HLA Object Model Template (OMT) Specification, and the HLA Rules. The Real-Time Platform Reference Federation Object Model (RPR FOM) has also been nominated as a standard.

- Data Exchange Standards. The next generation of the DIS Protocol Catalog will include data exchanged in other classes of simulations, and will provide a resource for developing object models for HLA applications. The Standard Interchange Format (SIF) will be replaced by the Synthetic Environment Data Representation Interchange Specification (SEDRIS). SEDRIS is a format-independent data representation model for interchanging synthetic environment databases, including any combination of (but not limited to): terrain, ocean, atmosphere, three-dimensional icons/models, features, topology, sound, textures, symbols, and special effects.

## STATUS OF FY97 AMIP FUNDED PROJECT

There were no projects awarded for the Architecture standards category during FY96.

## PRIORITIES FOR NEXT YEAR

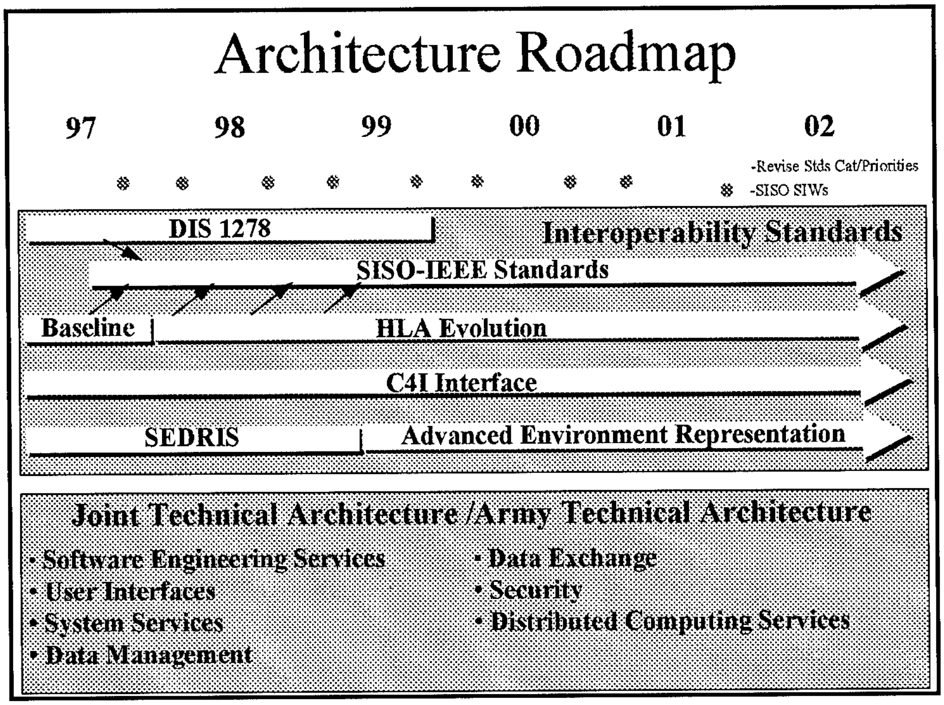
The Architecture Standards Category Team met at the Army M&S Standards Workshop on 5-8 May 1997. At the workshop, the team redefined the architecture requirements to include the need to develop an awareness of evolving architectures such as VRML and DWN. The team also revised the list of architecture shortfalls for FY98, based on the Architecture Roadmap.

- DIS 1278 Transition to SISO. The Army will continue to support the transition from DIS 1278 to SISO. The transition support will include hands-on HLA education for the M&S community, as well as support for the development of tools to aid in the transition. In addition, the Army will continue to support the HLA standardization effort by actively participating in the SISO and the SIW. The SISO currently operates as a sponsoring organization under the jurisdiction of the IEEE Computer Society Standards Activity Board.

HLA Transition Period. The HLA will continue to be refined by the Architecture Management Group (AMG). DMSO will be responsible for configuration management, technical assistance, and related activities as DoD programs incorporate the HLA. Additional HLA draft specifications will be nominated as standards to the SAC. The specifications will address compliance testing, time management, data management and data distribution management, security, and other applicable areas. Development, prototyping, experimentation, and user support with the RTI will continue.

## ROADMAP

The Architecture Roadmap extends from FY97 to FY01.




## AMIP PROPOSALS

Three project nominations were submitted for FY98 AMIP funding under the Architecture Standards Category. These are listed in descending order of importance to the architecture standards process. The titles are listed below:

1. Using the HLA Object Model Template for Simulation Specification
2. Domain-Based Data Collection Support for the High Level Architecture
3. Test Federate Scripting Tool

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# ATTRITION

## STANDARDS CATEGORY DEFINITION

The Attrition Standards Category addresses the algorithms and processes that encompass the selection, prioritization and engagement of targets and the subsequent battle damage assessment and disengagement of combatant forces. Also included within this framework are physical processes that represent the probabilities of hit/kill for both direct and indirect fire weapon systems, effects of countermeasures, tracking and designation of targets, flyout of projectiles (including line-of-sight checks as appropriate), and ammunition expenditure.

## STANDARDS REQUIREMENTS

The standardization objectives of the Attrition category include the following:

- Establish standard attrition methodologies,
- Facilitate use of standard attrition methodologies by the M&S community,
- Improve known weaknesses, and
- Investigate the adequacy of current methodologies and replace where deficient.

## ACCOMPLISHMENTS AND ASSESSMENT

A significant milestone within the Attrition category was reached when the "Compendium of High Resolution Attrition Algorithms" was published in October 1996 as AMSAA Special Publication No. 77. This document was the culmination of efforts by a large number of analysts from AMSAA, ARL and TRAC-WSMR. The compendium documents standard Army algorithms used in high resolution attrition modeling. They are proposed as standard algorithms in the development of future high resolution simulations and simulators for distributed environments. The compendium's focus is primarily on ground combat, attack helicopters and ground-based air defense. The areas addressed include vulnerability modeling and the physical aspects of attrition for various categories of weapon systems: direct fire weapon systems, indirect fire weapons systems, ground-based air defense systems, and minefields. The behavioral and cognitive aspects of attrition are also included.

Efforts were initiated within the category to begin the development of a companion volume to the published high resolution compendium which will document aggregate resolution attrition algorithms for use in lower resolution models. A detailed outline was produced and draft versions of an introductory chapter and a chapter on ground-to-ground direct fire attrition were written. This work was included as a AMIP proposal for FY98 and is intended to be a joint effort among AMSAA, TRAC-FLVN and CAA.

The Attrition Standards Category had one AMIP-funded project for FY97. This project involves the development of a portable DIS lethality server and represents an attempt to address the second objective for the Attrition category listed above. The principal goal of the project is to develop a vulnerability/lethality information distribution tool for DIS, and eventually, the HLA repository. The server will be a means for increasing operability for all DoD DIS simulations, allow

DIS M&S to be developed faster, and reduce DIS pre-exercise preparation. The server components include : a database containing vulnerability/lethality look-up tables and DIS entity enumerations; a DIS network monitor for packing/unpacking DIS PDUs and event (shot) accounting; and a TCP/IP client/server link to conduct client/server hand shaking and communications. The effort was on schedule to be completed by the end of FY97 and will be an important step forward for vulnerability/lethality simulation in DIS exercises.

The AMSO Army M&S Standards Workshop during 5-8 May 1997 provided the opportunity to review in detail the various physical processes which fall under the attrition category umbrella. Representatives from TRAC-FLVN, ARL, CAA, AMSAA and the Army PA&E office discussed each of the category areas to: determine where interfaces with other standards categories should exist, assess the status of documentation and adequacy of methodologies, identify deficiencies, and prioritize future efforts. The workshop was a good forum for allowing the category members to engage in important discussions within their designated area and explore interface opportunities with other categories.

**PRIORITIES FOR NEXT YEAR**

With the successful publication of the Compendium of High Resolution Attrition Algorithms during FY97, it is expected that several attrition algorithms will be put into the evolving review and approval process being developed by AMSO for Army standards. This should help to formally recognize those methodologies as standards within the M&S community.

One of the main thrusts for next year will be the development of the Compendium of Aggregate Attrition Algorithms which will document the attrition methodologies currently used in division, corps and theater level models in the Army. Current plans call for the completion of the first draft and initial review by the end of FY98, with the final document to be published by mid FY99.

Another important effort will be to provide support for JWARS model development. A review of model requirements as well as current aggregate attrition methodologies will be conducted with the intention of providing ODCSOPS with a recommendation for an approach for modeling attrition in JWARS. During FY97 a significant amount of attrition-related data and documentation was provided to ODCSOPS. The emphasis for the near future is on providing attrition modeling guidance. It is anticipated that the methodology review will be conducted during the Fall of 1997 with a recommendation developed by the end of the 1997 calendar year.

Other efforts within the category will be focused on investigating methodologies and developing standard approaches in the following attrition areas:

- Disengagement criteria,
- Chemical/biological kill/damage effects,
- Directed energy weapons,
- Vulnerability metrics, and
- Non-lethal effects.

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## COMMAND DECISION MODELING (CDM)

### STANDARDS CATEGORY DEFINITION

Algorithms that model or simulate human behavior that results in an action taken, a decision or reaction being made or a plan being formed.

### STANDARDS REQUIREMENTS

a. Objective - Advance the art of modeling decision making processes for SAFOR, CGF, and constructive simulations.

b. FY98 Goals:

1. Develop a planning process standard.
2. Develop a battle management language standard.
3. Develop a framework for representing command knowledge.

### ACCOMPLISHMENTS AND ASSESSMENT

a. Accomplishments.

(1) A command decision modeling laboratory (hardware and software) has been established at the National Simulation Center to support the CDM standards category. Contractor support was obtained to assist in the design and setup of the laboratory and to continue research and assessment of government, industry, and academic CDM technologies. Currently, the laboratory is supported by four personnel. The aims of the laboratory are:

- To develop a common understanding of the requirement for modeling of the military command decision making process.
- To develop an understanding of the state of the art in modeling the command decision making process.
- To identify the capability shortfall and potential techniques and technologies for satisfying the shortfall.
- To coordinate research activities to offer the most cost effective approach to meeting requirements.

(2) We have been working with ARI and their C3SIM, examining C3SIM for use as a PC based command agent prototyping environment. We have also met with the University of Illinois which provided us with their efforts to develop an evolutionary programming based COA tool. Our laboratory configuration provides the versatility needed to host these various applications as well as Army based efforts such as Eagle-AP and ModSAF.

(3) We have been assessing commercial wargame engine technology and feel that these wargames can help provide insight into the area of human computer interface design. This is because each game provides the user with a large amount of information accessible through a single workstation/PC with unit control ranging from Bn to Plt. Commercial wargames we have examined include; TACOPS, CloseCombat, Across the Rhine, Steel Panthers II, and Perfect General II. With

the exception of TACOPS, all games examined have been based on WWII.

(4) Between Mar 97 and Jul 97, we have been working with the WARSIM Contractor and STRICOM to establish Eagle-Adversarial Planner (AP) in the Orlando testbed. A complete system was provided and setup in the testbed for study of this CDM technology and assessment of its potential for reuse in WARSIM 2000. Two weeks of on-site classroom training and hand-on demonstrations were provided. We continue to work with the WARSIM testbed and are currently planning future collaborative efforts. In the near future we plan to virtually link both laboratory environments to collaborate on CDM prototype development.

b. Assessment.

A significant community interest continues to exist in developing methods for simulating/stimulating battlefield operations involving commanders and their staffs. Future programs such as WARSIM 2000, JSIMS, JWARS, and OneSAF will rely on CDM technology and standards to significantly reduce the number of controllers and role-players required to provide a higher level of fidelity play. Although a significant amount of research still needs to be conducted to develop CDM techniques throughout the M&S community, there are several areas where normative standards can be produced based on completed efforts. Three such areas ready for M&S standards development are the military planning process, a battle management language to support C4I connectivity and a methodology for generic knowledge representation.

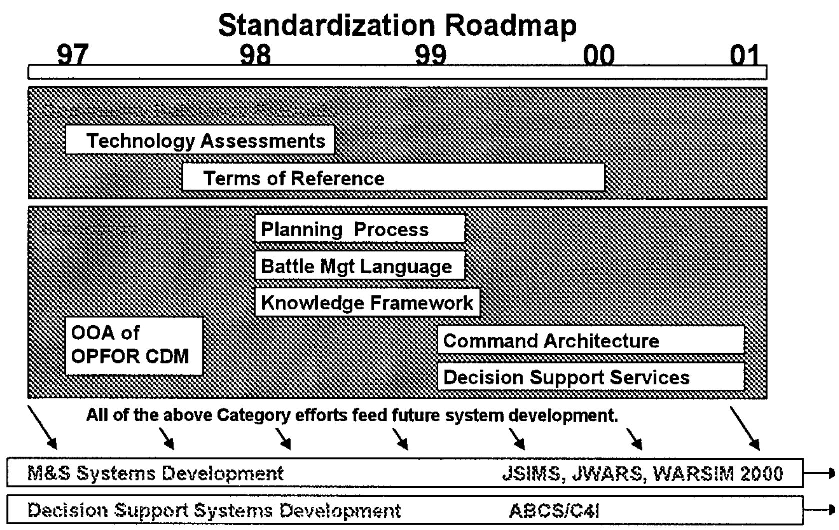
**PRIORITIES FOR FY98**

Key efforts will focus on:

- Development of normative CDM standards for the M&S community.
- Continuing to canvass the community for additional assessments of command decision modeling technology.
- Conducting research on and prototyping of command agent architectures, normative behavioral models, and object-oriented behavioral representation.
- Continued expansion of the CDM world-wide web page into a repository of information for command decision modelers.
- Development of the CDM reflector forum supporting open community discussion of standards, technology, and implementations.

## ROAD MAP

The following figure highlights the long term goals of the CDM standards category.




The following organizations/individuals have made key contributions to this standards category and are members of the CDM Team:

| Name | Organization | Position |
|---|---|---|
| Sean MacKinnon | NSC | Chair |
| Marilyn Macklin | DCSINT | Co-Chair |
| Barbara Pemberton | STRICOM | Member |
| Dave Hoffman | TRAC-WSMR | Member |
| Dr. Chris Barrett | LANL | Member |
| Dr. Chris Elsaesser | MITRE | Member |
| LTC Robert Hammel | ARL | Member |
| Janet Morrow | NGIC | Member |
| MAJ Bruce Simpson | Army AI Center | Member |
| Dr. Phil Gillis | ARI | Member |
| Penny Mellies | TSD - DCSINT | Member |
| LTC(P) Doug McGregor | BCBL | Member |
| Helen Lankester | UK DERA | Member/Observer |
| Dick Brown | TPIO-ABCS | Member |

This list is not all inclusive and membership is open to all government agencies, academia, industry as well as international participation. The CDM SCC typically distributes reports and other information to 40 plus members. This truncated list represents those that have been most active in supporting the standards category.

## FY98 AMIP PROJECT PROPOSALS

The following proposals received AMIP funding for FY98.

- Command Planning Process Standard.
- Battle Management Language and Knowledge Representation Standard.

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# CONTROL, COMMUNICATIONS, AND COMPUTER SYSTEMS REPRESENTATION

## STANDARDS CATEGORY DEFINITION

Control, Communications, and Computer Systems Representation. The Control, Communications, and Computer Systems Representation category standards includes the objects, algorithms, data, and processes necessary to replicate friendly and enemy control, communications, and computer systems and processes.

## STANDARDS REQUIREMENTS

The standards requirements as described in the Army Model and Simulation Plan are:

1. Define and design objective control, communications, and computer systems M&S representation.
2. Coordinate common control, communications, and computer systems representations with other categories.
3. Upgrade current M&S capabilities to replicate existing and emerging control, communications, and computer systems.
   In addition the following requirements are also in need of standardization:
4. Insure design will permit systems interface with other M&S in the constructive and virtual worlds.
5. Insure HLA compliance is part of the development of new M&S communications models.
6. Provide for data interchange of allow communications effects to play in combat models.
7. Develop MOE's to identify key elements and validation tolerances for control, communications, and computer M&S.
8. Insure the models are available to users.

## ACCOMPLISHMENTS AND ASSESSMENT

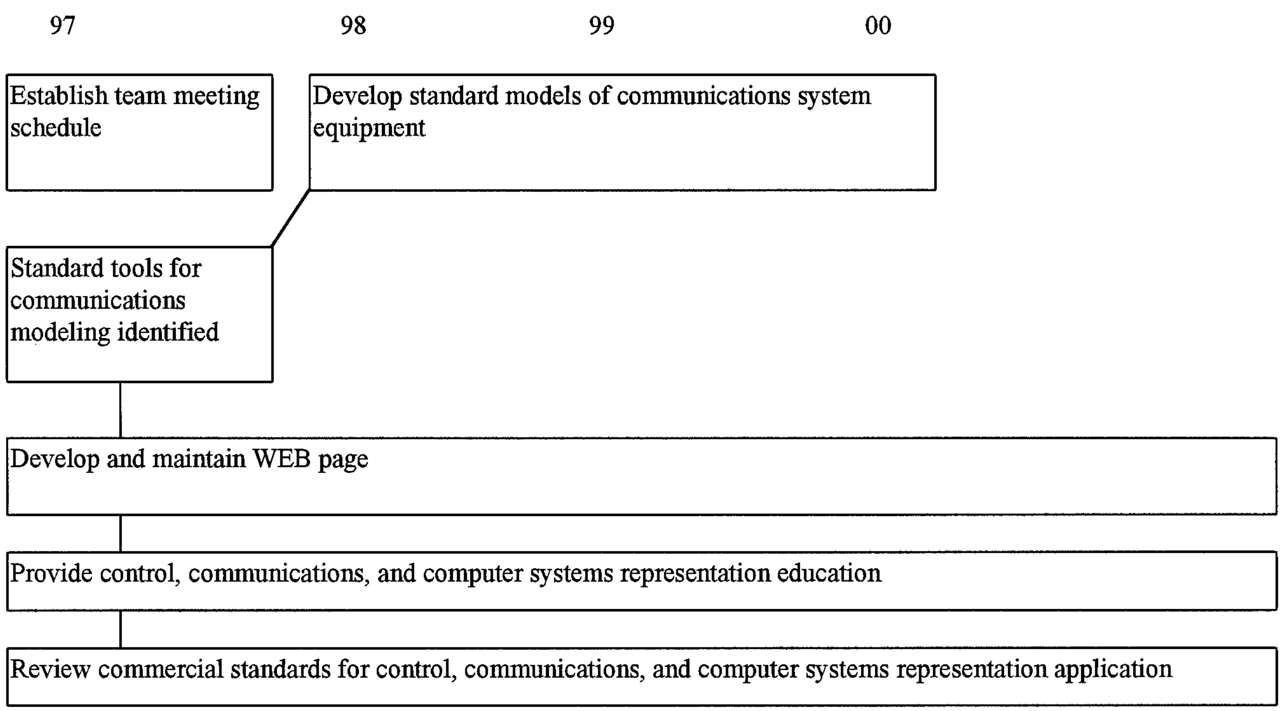
- Team Building: Team invitations have been sent to those government agencies who are involved in the development of C4 doctrine, architecture, and the acquisition of hardware/ software to support the mission needs. Representation from ADO, CECOM, ARL, and SIGCEN attended the M&S workshop held at Carlisle Barracks Pa. on 5-8 May 1997. Discussion on the AMIP project submissions was held and there are two projects to be presented. The team has suggested that an additional category be established to cover the intelligence community concerns in the area of Intelligence, Surveillance, Reconnaissance.

- A WEB page is in the process of development and will be established within the next 6 to 8 months. In addition research and eventual establishment of a repository for M&S tools useable for communications systems modeling will be accomplished. Modeling of communications systems is under upgrade. The major development tool of choice is a commercial product entitled OPNET. Involved in this development is the need to set parameters under which OPNET developed modules must operate. Interchangability is a primary requisite for these parameters, and will insure usability regardless of who develops the module.

**PRIORITIES FOR NEXT YEAR**

1. Increase membership in the team.
2. Finalize the Web page.
3. Complete definition of a repository - Determine procedures for operation and insure configuration management is applied.
4. Obtain communications module information and compile a list of available OPNET modules that can be used by the M&S community.
5. Specify standard terrain and force structure to be used as a baseline for modeling.
6. Develop methodologies that can be used as standards.
7. Provide Education

**ROAD MAP** for Control, Communication and Computer Systems Representation



# Annual Standards Category Report for FY98

# COST REPRESENTATION

## STANDARDS CATEGORY DEFINITION

The Cost Representation standards category addresses Army standard cost element definitions, the data tools, algorithms and techniques necessary for accurate costing and consistent portraying all appropriate elements for activities depicted in models and simulations.

## STANDARDS REQUIREMENTS

Develop a means to cost all appropriate elements portrayed in models and simulations. Standardize techniques for comparing cost alternatives. Army cost standards and guidance are contained in three documents: AR11-18, The Cost and Economic Analysis Program; The Department of the Army Cost Analysis Manual; and the Department of Army Economic Analysis Manual.

## ACCOMPLISHMENTS AND ASSESSMENT

The U.S. Army Cost and Economic Analysis Center (CEAC) is responsible for Cost Representation. During the last year, CEAC has developed, improved and fielded cost estimating tools and models and cost databases. Major accomplishments are as follows:

Update of the Automated Cost Estimating Integrated Tools (ACEIT) to the reduce calculation time, enhanced import/export capabilities, linkage to Automated Cost Data Base (ACDB), addition of RI$K Executive, and installation on a single CD ROM disk. ACEIT is the standard Army automated framework/spreadsheet that is designed to improve reporting consistency and increase productivity of cost analysis work. The Army, Air Force and the Navy endorse ACEIT as the recommended tool for their cost analysts to use. ACEIT automates the detailed, tedious costing functions and documentation allowing the analyst more time to concentrate on the methodology and perform analysis. The ACEIT model is under continual improvement. ACEIT includes a Cost Analysis Statistical Package (CO$TAT) that focuses on the needs of cost estimator for risk analysis. ACEIT planned updates include linkage to the Army Manpower Cost System (AMCOS) model, a personnel costing model. AMCOS addresses costs of active military, reserve (Army and National Guard), and civilians by grade and MOS/skill. CEAC continues to train analysts in the use of ACEIT. ACEIT enhancements are planned to improve Cost as an Independent Variable (CAIV) capability.

Automated Cost Data Base (ACDB) contains cost, technical and programmatic data from Contractor Cost Data Reports (CCDRs), Contractor Performance Reports (CPRs), contracts and other sources. The missile database was the initial module. ACDB is improving the search and retrieval interface. ACDB is planning to add an Aircraft module, Composite materials database, and Wheel and Track Vehicle Module.

Force and Organizational Cost Estimating System (FORCES) is a suite of models including a force cost model, force cost factor database, cost factors handbook, military end strength reduction model and civilian manpower reduction model. FORCES is updated annual and distributed to the field.

Operating and Support Management Information System (OSMIS) is an automated database of normalized, actual material operating costs used for Army OPTEMP budgeting and Operating and

Support acquisition costing. This data is collected annually, analyzed, distributed and used Army-wide.

CEAC has provided guidance to the field in the form of the Department of the Army Cost Analysis Manual and the Department of the Army Economic Analysis Manual. CEAC provides expert guidance for all Army cost estimating issues and/or questions.

**PRIORITIES FOR NEXT YEAR**

1. Maintain current information on the web site www.asafm.army.mil\CEAC. htm.
2. Integration of the various models and databases (CCDR, OSMIS, FORCES, AMCOS and ACEIT).
3. Review Department of the Army Economic Analysis Manual to determine if an update is needed to reflect the changing Army environment.
4. Provide validation and verification on the use of cost in models and simulations, as required.
5. Provide support to improve and expand existing cost methods and databases.
6. Develop new data, tools, algorithms and techniques necessary for accurately costing all appropriate elements of activities portrayed in models and simulations.
7. Continue horizontal and vertical integration of cost representation functions with those of the other models and simulation domains. Coordinate with other standard categories to ensure that changes impacting costs are evaluated.

## Annual Standards Category Report for FY98

## DATA

### STANDARDS CATEGORY DEFINITION

The Data Standards Category is defined as encompassing all areas that increase information sharing effectiveness by establishing standardization of data elements, database construction, accessibility procedures, system communication, data maintenance and control. This category includes, but is not limited to, the development and maintenance of standard nomenclatures, standard data element representation, standard procedures for data verification, validation, and certification, data modeling standards, standard query languages and other software standards related to databases and data visualization tools, and standard means for the transfer of data between organizations. This category is limited to data used for modeling and simulations within the Army and includes item level performance data and characteristics (for Blue, Red, and Gray systems), logistics data used in Army M&S, environmental effects data, Army generated terrain data and test data. The Data Standards Category does not address data standards for cost, other financial data, personnel data, and terrain data produced by the Defense Mapping Agency.

### STANDARDS REQUIREMENTS

The need for reliable and accessible data in standardized formats is one of the most frequently cited issues for Army M&S. Priorities for the Data Standards Category have been established to:

1. Promote Data Standards. Effective data communication begins with standards in format, content and naming of items. Without these items, users of data cannot be certain that they are correctly representing the items in models and simulations. Priority should be given to the identification, proliferation and incorporation of standards into new and existing databases.

2. Develop Infrastructure. Resources should be devoted to the development and maintenance of the infrastructure required to support data standards. This infrastructure includes, but is not limited to, data modeling tools, computer hardware and software, data dictionary efforts, and networks required for linking databases for information exchange. An Army-wide M&S Common Data System would be the hub of this infrastructure.

3. Automate Existing Databases. Some Army organizations that have a recognized mission to provide data for M&S do not have automated database management systems in place for their data. Without the use of automated database management systems, it is extremely difficult to develop and maintain data standards for complex technical data to support M&S. Priority should be given to the identification and automation of these existing databases.

4. Develop New Databases. To develop and maintain data standards for M&S data, it is important to develop databases in those technical areas where new categories of data are being produced and used in M&S for the first time.

5. Expand Education. Education includes training and data standards consultations. It is important for agencies to remain abreast of ongoing standards projects by conducting and participating in seminars, symposia, newsgroups, and workshops on data and repository standards for M&S applications.

These objectives are the foundation for establishing creditable data standards that will enhance and promote information exchange throughout the Army and across DoD. The validity and flexibility of M&S are contingent upon standard, certified data.

## ACCOMPLISHMENTS AND ASSESSMENTS

The Data Standards Category Group met at Carlisle in May. Revisions were made in the group's vision (see vision section below) and requirements (Appendix B).

AMIP co-sponsored an FY97 task with the Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME) and the US Army Materiel Systems Analysis Activity (AMSAA) for an AMSAA-JTCG/ME Joint Database. The overall goals of this task were to standardize performance estimates and methodologies between AMSAA and the JTCG/ME. In doing so, standardization in data elements, products, and nomenclatures are also standardized. The following tasks have been accomplished:

1. Development of a task management plan.
2. Development/coordination of detailed task requirements.
3. Standardization of indirect and direct fire effectiveness methodologies that produce the performance data used by Army and joint service study agencies.
4. Standardization of representation of direct fire and indirect fire performance estimates that are used by Army and joint service study agencies. A DoD data standardization package has been prepared.
5. Resolution of differences in AMSAA and JTCG/ME direct fire legacy data (vulnerability files and reliability data) and loading of data.
6. Resolution of differences in AMSAA and JTCG/ME legacy data for indirect fire systems (vulnerability data, fragmentation data, ICM characteristics, and accuracy data) and loading of data. A white paper detailing the differences was developed.
7. Construction of an "architecture" to maintain and provide configuration control for vulnerability and fragmentation files. The architecture is the means by which consistency between the two organizations is achieved. This effort included the development of utility programs that converted vulnerability files (cell by cell files) to a standard self-documenting format.
8. Implementation of configuration control for models and data.

This project supports Army data standards initiatives by providing common representations across AMSAA and JTCG/ME. These data can be used to support Army and joint service studies. The data have been compared with similar Navy, Marine and Air Force systems. The combined database positions the Army in a leadership position for supporting joint studies.

## PRIORITIES FOR FY98

The focus of the Data Standards Category for FY98 will be on Developing and Implementing Data Standards and developing Infrastructure. Data standards subsume all of the objectives in the Army M&S Master Plan. Data and repositories are the foundation of Automated Information Systems, and therefore are an integral part of providing a common M&S technical framework.
Timely study completion is becoming increasingly dependent on efficient data management and communication. The tools for managing and transmitting data are available. The key is implementing

data standards so that data can be "seamlessly" imported into other databases and applications programs.

## ROAD MAPS

The goal of the Data Standards Category Group is to develop an infrastructure which will provide a basis for better interoperability and reuse of consistent and quality data throughout the M&S community.

The Army has been actively working toward standardization of Army M&S data for some time. Efforts are underway to standardize dictionary items, nomenclatures, icons (pictures and symbols), data interchange formats, and authoritative data sources.

Repositories like the Defense Data Dictionary System (DDDS) and the Defense Data Repository System (DDRS) were established to provide standard definitions, formats, and other metadata to describe data. The ADD is currently working to merge its resources into the DDR to provide a single DoD repository for the dictionary standards. Inputs to the DDR are ongoing and continuous as new data are standardized.

It has long been noted that the way items are identified in DoD is not consistent across its organizations. This has led to confusion and misidentification or misinterpretation of items. It is imperative that in this joint electronic environment that the identification of an item is exact and consistent. Organizations have been working to establish vehicles to promulgate standard nomenclature or enumerations, like TRAC's Standard Nomenclature Database and the DIS Enumeration Document.

DoD, in conjunction with the services, is working to establish a list of authoritative data sources. The list will include data producer and data center responsibilities. An initial list was made available on the world-wide web in 2QFY96.

Education is a continuous process. Managers and users must become familiar with the standards that exist and possess a willingness to adhere to the same. Once organizations start to use other compatible applications and tools in their applications, they will immediately see the benefits of reuse.

## DATA STANDARDS CATEGORY VISION

Data is the medium that feeds all models, simulations, and simulators. As M&S applications become more sophisticated, their hunger for data increases exponentially. The currency, accuracy, and timeliness of the data is the foundation of any good exercise involving M&S tools. Someday, every customer will be able to access the data they need, instantaneously.

The use of data and repository standards are an absolute precursor to an Automated Information System (AIS). How data are created, stored, exchanged, and used are determined by specific sets of guidelines. These guidelines must be exact for an AIS to function. The standards set for data subsume all other Standards Categories.

The Data Standards Category vision is to promote efforts which will lead to data access, sharing, and reuse by:

- Identifying authoritative data sources,

- Communicating what data is where,
- Standardizing the data interchange formats,
- Standardizing the data taxonomy and item names, and
- Improving the availability of data by fostering the use of databases

and improving the consistency and quality of data by:

- Implementing data verification, validation, and certification procedures and
- Leveraging investment legacy data produced by models, simulations, and tests using expert systems to estimate performance where limited information exists.

## AMIP PROPOSALS

The following proposals were submitted by the Data Standards Category for AMIP funding for FY98. The submissions were prioritized in accordance with the overall objectives of this standards category and with the impact of the projects on the community at large.

1. Characteristics and Performance (C&P) Data Interchange Format (DIF).
2. Army M&S Data Engineering Technical Framework (DE-TF).

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# DEPLOYMENT AND REDEPLOYMENT

## STANDARDS CATEGORY DEFINITION

Deployment and redeployment standards address objects, processes, procedures, techniques, algorithms, and other elements needed to accurately portray the relocation of military and civilian forces from the origin to the area of operations, and the preparation for and movement of forces from one area of operations to follow-on designated CONUS or OCONUS bases or areas of operations.

The functional definitions for deployment/redeployment are as follows:

Deployment: The strategic relocation of military and civilian forces (personnel, equipment, and supplies) from home station to desired area of operations; or the tactical movement of forces within areas of operations (FM 100-5). The critical factor is to get the required forces to their destination when they are needed and in condition to meet their mission requirements. Deployments may take the form of a forcible entry for crisis response or unopposed entry for natural disasters or humanitarian assistance (FM 100-17).

Redeployment: The preparation for and movement of forces from one area of operations to follow-on designated CONUS or OCONUS bases, usually after the combatant commander has achieved conditions favorable to US interests. The key to redeployment is that it should not be considered as retrograde movement, but in fact as a new deployment. Redeployment must involve force integrity so that units may be diverted anywhere, ready to fight (FM 100-17). Emphasis may be on efficiency as opposed to time.

As a side note, DoD has made much progress in the deployment modeling and simulation (M&S) arena that has not yet been extended to the complexities of redeployment. As a result, the following assessment describes deployment only. By setting the standards for deployment, we are inherently developing the standards for redeployment M&S.

## STANDARDS REQUIREMENTS/OBJECTIVES

- Develop modeling standards that address all deployment domains (ACR, TEMO, RD&A, execution, planning, analysis, training, etc...) and all the joint end-to-end process elements
- Develop a common object structure for the representation of all aspects of deployment/transportation, including forces (equipment, personnel, and supplies), transportation assets, cargo, and infrastructure.
- Develop and document deployment related objects, entities, actions, algorithms, processes, etc... at various levels of resolution.
- Ensure commonality and linkages with mobilization, logistics, and warfight simulations.

## ACCOMPLISHMENTS AND ASSESSMENT

Developed and posted the category home page on the MTMCTEA web site (www.tea-army.org).

While several Army and DoD organization are using and developing deployment models and simulations, to date, no service or agency has standardized these models and simulations. Most of the requirements and standards development is at the individual organizational level. The overall status of the Deployment Standards Category is red.

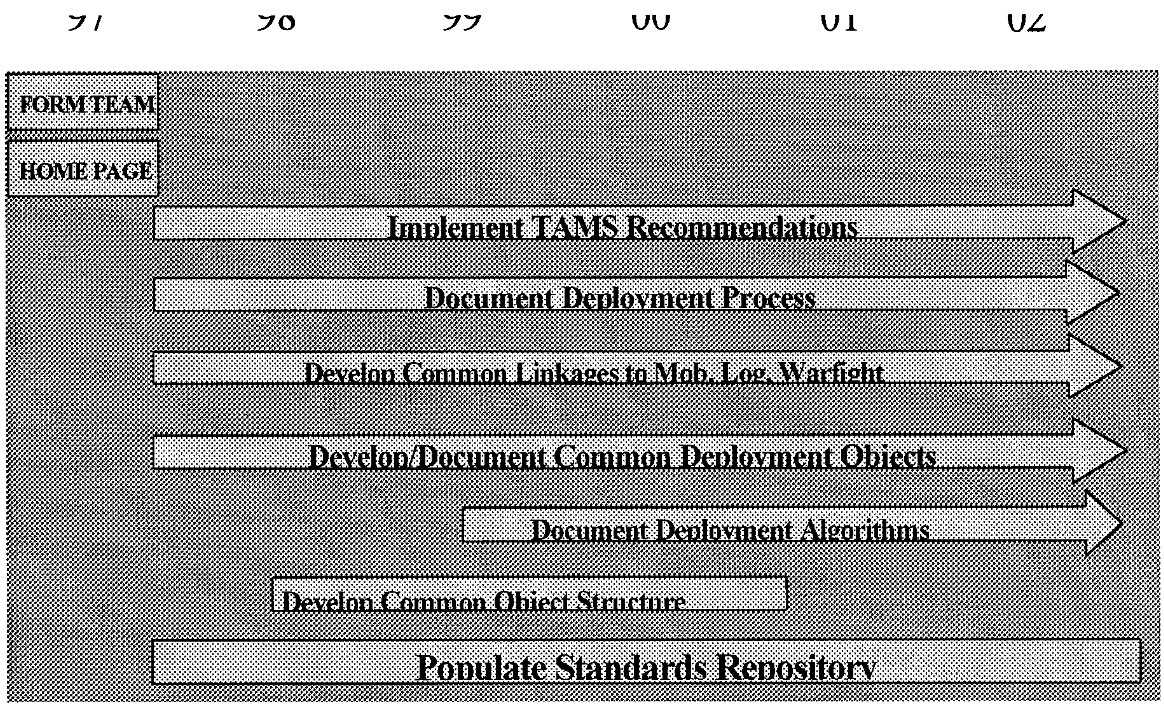
However, the outlook for improving upon this status is excellent. There are currently several efforts underway to bring together those in the functional deployment community. One major effort is the Transportation Analysis, Models and Simulations (TAMS) initiative. TAMS is a US Transportation Command (USTRANSCOM) Joint Transportation CIM Center (JTCC) initiative to assess and make recommendations on deployability/mobility modeling and simulation tools in use throughout DoD. The JTCC has an OSD charter to make recommendations on migration systems. The TAMS vision is to provide an end to end transportation planning system that supports multiple levels of modeling and simulation. In 1996, USTRANSCOM/JTCC held several workshops to define the current "As-Is" capabilities of mobility M&S. It also held several "To Be" workshops to determine requirements for transportation planning, migration systems to support the Global Transportation Network (GTN), and the Joint Simulation System (JSIMS) and Joint Warfare System (JWARS). Participants in the TAMS workshops included USTRANSCOM, the warfighting CINCs, the Joint Staff, OSD, and the Services.

The TAMS initiatives will provide a good foundation for the development of requirements (and standards) for deployment M&S. However, continued teaming and investment is necessary to further develop these and other standards and ensure deployment M&S comply with Army and DoD standards such as the HLA.

## PRIORITIES FOR NEXT YEAR

The focus for FY 98 will be on teaming, developing a common deployment object library/hierarchy for M&S, and developing standard linkages between deployment, employment, mobilization, and logistics models and simulations.

**ROAD MAP**




***COORDINATE AND GAIN CONSENSUS THROUGHOUT!***

**FY 98 AMIP PROPOSALS**

1. Development of an Extensible Hierarchy and Object Representation for Deployment Models and Simulations.
2. Global Deployment Analysis System: Conversion to High Level Architecture (GDAS-HLA)

*Deployment/Redeployment*

**Annual Standards Category Report for FY98**

# DYNAMIC ENVIRONMENT

## STANDARDS CATEGORY DEFINITION

The battlefield environment includes many sources of aerosols and particulates such as chemical/biological agents, smoke, dust, fog and chaff. These add to the natural environment increasing the presence of non-uniform aerosol regions. Weather, atmospheric transport and diffusion processes, and the attenuation and scattering effects of the environment on the propagation of electromagnetic energy all impact target acquisition and high technology weapons. The atmosphere and clouds provide cues, alter target and background signatures, and produce scene clutter both in the real world and in realistic computer-generated simulations.

The Dynamic Environment (DE) category definition includes the objects, algorithms, data and techniques required to replicate weather, weather effects, background changes due to environmental effects, effects on acoustic propagation, and transport and diffusion of aerosols as battle by-products in models and simulations.

## STANDARDS REQUIREMENTS

To correctly visualize a scene, whether for situational information, for tactical planning, for atmospheric effects on sensors and target acquisition, or for realistic simulations, physically correct or natural atmospheres must be included in environmental representations. These environmental representations are objects, data sets and algorithms that can be used to describe the complex environment and to support effects calculations. A scenario-specific natural environmental representation can be pre-computed or pre-scripted (if time-varying) for later real-time simulations. Atmospheric parameters and effects must be represented such that natural environmental realism is preserved.

Embedded environmental processes include battlefield-generated clouds, from munitions, vehicles, agents and fires, and countermeasures chaff and flares whose location and time of introduction cannot be completely pre-scripted. They are event-driven, resulting from battle actions and combatant decisions. Thus, they can only partly be pre-computed. These processes are embedded into the natural aerosol environment and are generally more localized and dynamic than other battlefield effects. Atmospheric parameters and effects from embedded processes are thus both super-imposed on and affected by input conditions described by the natural environment representation. In some cases the environmental embedded processes will be the dominant factors in determining the outcome of a simulation.

Current DE requirements are to:

- Provide Fundamental Environmental Data for M&S
- Provide Consistent Data for Environmental Effects Models
- Provide Standardized Data Bases for System Performance Analysis
- Provide Sets of Standard Synthetic Natural Environments

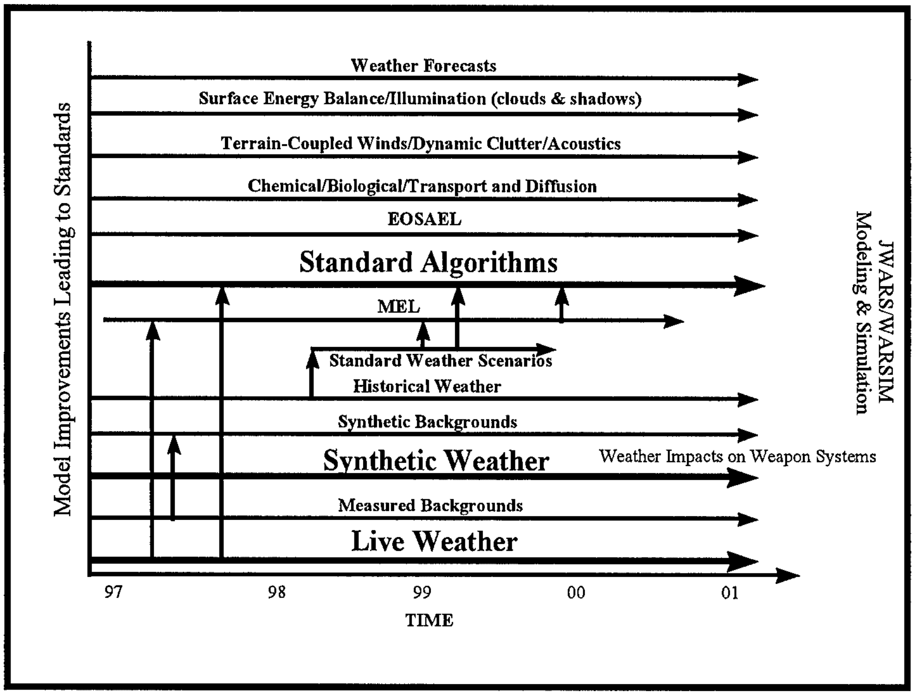



**Figure 1. Dynamic Environment Roadmap**

In concert with these requirements the DE category has the objectives of ingesting live meteorological data and real-time forecasts into simulations along with development of: fundamental dynamic environment databases to support modeling and simulation; standard synthetic natural environment scenarios and backgrounds; and standard tools to facilitate system performance analyses. The final objective is to adopt algorithms for standards in the areas of terrain-coupled winds, surface energy budget, dynamic clutter, acoustics, illumination, and clouds and shadows. These objectives are embodied in the dynamic environments category roadmap (Figure 1).

## ACCOMPLISHMENTS AND ASSESSMENT

### Assessment

The three major areas in DE are (see Fig. 1) live weather, synthetic weather and standard algorithms. The first two (live and synthetic weather) are necessary for the modeling and simulation community to use in accurate live, constructive and virtual simulations; they are also needed for the algorithms leading to standards in the DE category. Live weather can be provided by the fielded tactical Integrated Meteorological System (IMETS). IMETS is the meteorological component of the Intelligence and Electronic Warfare sub element of the Army Battle Command System. IMETS provides commanders at all echelons with an automated weather system to receive, process, and disseminate weather observations, forecasts, and weather and environmental effects decision aids to all Battlefield Operating Systems. Measured backgrounds are represented by the Cold Regions Research and Engineering Laboratory's (CRREL) Smart Weapons Operability Enhancement (SWOE) program.

Synthetic backgrounds are also addressed by SWOE and the Army Research Laboratory's (ARL) CREATION model. CRREL and ARL are working jointly on improving their models; both are discussed further below. Historical weather, leading to derived weather scenarios, is represented by data archived in the Air Force's Combat Climatology Center and the Defense Modeling and Simulation Office's (DMSO) Master Environmental Library (MEL) program, also discussed below.

Modeling efforts, discussed in some detail below, leading to the development of standard algorithms in the DE area are, as might be expected, strong in some areas and in need of additional effort in others. The Electro-Optical Systems Atmospheric Effects Library (EOSAEL) is being proposed as a standard in the DE and Acquire categories. EOSAEL was developed by ARL to quantify the propagation environments expected on battlefields. The development of transport and diffusion models for chemical and biological agents is actively being worked as is the related area of terrain coupled winds. This latter area is being addressed by a number of similar, but non-duplicative, efforts. One such effort is ARL's High Resolution Winds (HRW) model which couples boundary layer winds to terrain. Another effort is the Transport, Diffusion, and Radiance (TDR) model, a COMBIC derivative developed for the U.S. Army Edgewood Research, Development, and Engineering Center, the Joint Project Office for Special Technology Countermeasures, and the Naval Surface Warfare Center. TDR can be run with a homogeneous or non-homogeneous wind field to produce realistic results over complex terrain. Another effort for coupling smoke to the battlefield is the Army Modeling and Simulation Office's (AMSO) FY97 sponsored Environmental Effects for Synthetic Test and Training Assessment Ranges (E2STTAR) Army Modeling Improvement Plan (AMIP) project. Dynamic clutter is being addressed by the Night Vision and Electronic Sensors Directorate's (NVESD) Image Based perception program and also by TARDEC. Acoustics is being developed by ARL as are the effects of clouds and shadows on illumination. The surface energy budget, dependent upon solar flux, is important for determining the ground state and also for dynamic target signatures. This area is currently being expanded by the FY98 AMSO AMIP project, The Modeling of the Ground State in Winter Environments (GSWE). Illumination/cloud and shadow effects are being examined at ARL through the Weather and Atmospheric Visualization Effects for Simulation suite of models. In the area of weather forecasts, the Battlescale Forecast Model is being proposed as a standard in the DE category. Other areas of note are MICOM's Battlefield Environment Weapon System Simulation (BEWSS) which combines weapon system characteristics and battlefield environment models, NVESD's work on contrast and albedo effects, and ARL's work in multiple point source illumination and on the Integrated Weather Effects Decision Aids (IWEDA). Additional efforts are needed in/for dynamic target signatures and in weather database development, particularly for standard weather scenarios. These efforts are in concert the DE objectives stated above.

Teaming arrangements for the Dynamic Environments category include members from ARL, the Army Space and Strategic Defense Command, CRREL, NVESD, and the Training and Doctrine Command (TRADOC). Reports from FY 96 and 97's accepted proposals in the AMIP DE category (Advanced Atmospheric Modeling System for Combat Simulations and Environmental Effects for Synthetic Test and Training Assessment Ranges) will be found below along with the abstract from FY98's accepted proposal (The Modeling of the Ground State in Winter Environments).

## ACCOMPLISHMENTS

## ARMY MODELING IMPROVEMENT PROGRAM PROJECTS

### Advanced Atmospheric Modeling System for Combat Simulations (ATMOS)

Introduction: Five advanced atmospheric/obscurant modeling concepts were tested in the US Army CASTFOREM force on force wargame simulation. Comparisons of the combat Loss Exchange Ratios (LERs) and other metrics were made to determine the impact of the advanced models on the wargame outcome. Specific models tested were (a) COMBIC, the current standard, enhanced to include terrain elevation (b) ONION SKIN/SANDIA, enhanced to include terrain elevation, (c) ONION SKIN/SANDIA, enhanced with terrain sensitive high resolution wind fields, (d) COMBIC-RT, contrast transmission effects in COMBIC, and (e) COMBIC-PMW, turbulence effects on millimeter wave (MMW) obscurants. These models were compared with the standard COMBIC. As expected, scenarios in hilly terrain showed that the proper play of terrain effects in treating localized obscurants to be highly significant; generally giving rise to increased effectiveness of obscurants favoring blue by 13-20% in terms of kills. The effects of terrain induced wind flow on obscurant transport was less pronounced due in part to the fact that particular smoke sources in the scenarios were relatively short lived and thus relatively unaffected compared to long range transport. Contrast transmission was highly significant for visible band sensors generally giving rise to increased smoke screen effective lengths of a factor of two or more; however, the impact on the battle outcome depends upon other real world complexities such as the general force orientation and upon the availability of IR sensors to mitigate the effects on the visible band. Results for the MMW studies showed that atmospheric turbulence effects can cause the mass extinction coefficient to vary by a factor of three and this corresponded to an overall impact on MMW system kills of 8%, however, in some cases the differences were as high as a factor of five, depending upon engagement range. The study also revealed the difficulty in drawing simple conclusions from a highly complex task and we feel that many of our conclusion are scenario dependent and subject to some change based upon any number of practical considerations some of which are reported in the following paragraphs. Overall it can be said that, according to the study, the proper play of the advanced concepts gave rise to a change in the LER from 2.02 to 2.76 favoring blue. The most important effect was the play of terrain, followed by transport with high resolution wind, turbulence effects (for MMW obscurants) and contrast transmission (for visible band sensors). Although other models were used here to prove a point, it can also be generally concluded that, with the exception of high resolution wind effects, most of the model "fixes" can be done in the context of the current standard COMBIC model, some of which are currently being consider at ARL and TRAC WSMR.

Methodology/Findings: All of the studies were performed with the current TRAC/WSMR version of CASTFOREM using two different battalion level engagement scenarios; one with relatively hilly terrain (HR 3.5, or "BENCHD") and another with relatively flat terrain (HR58). In all cases we attempted to maintain the same general procedures used by the developer. Our only major modification to the scenarios, per se, was the placement of the smoke sources to demonstrate various environmental effects. Specific findings from the study are outlined in the following paragraphs.

a. Terrain Effects: The most significant finding of the study was the impact of playing terrain effects in the placement of obscurants. The current version of CASTFOREM does treat elevation in determining line of sight but not for smoke screens. This study determined that the impact on wargame statistics from playing smoke with corrected terrain elevation models was significant. We found that, in general, for blue weapon systems used in these scenarios, the number of blue kills increased by 20%

when using the SANDIA smoke model, by 13% when using the ONION SKIN model, and by 15% when using COMBIC. The increase number of blue kills is caused by the fact that, in the BENCHD scenario, much of the smoke occurs in a valley between the two forces , thus most of the engagements involve lines of sight that actually pass over the smoke screen when treated correctly, thus lessening the impact of the smoke. The effect in this scenario is if as smoke were not played at all. Interestingly, in these cases, the red kills do not increase as one might expect and this is due to the increased red attrition by the blue forces that survive.

b. Transport & Diffusion: This study also ran scenarios using SANDIA and ONION SKIN models in conjunction with terrain-induced complex wind fields. Results showed that the net effect on the number of red and blue kills were about the same (9% for blue and 10% for red) and thus nearly no change in the LER. Although we did note some effect of the terrain induced wind fields in transporting obscurants out of the field of view, we expected the differences to be larger due to the hilly terrain. However, the smoke sources, modeled as short lived discrete "puffs" in this particular scenario, dissipate fairly rapidly and since the complex wind field is defined only every 50 meters, the puffs do not have much of a chance to change directions. We believe that the differences would be larger for longer lived smoke plumes which, at the time of this study, could not be modeled with complex winds using either SANDIA or COMBIC.

c. Visible Band Sensors: Results showing the effect of solar angle, solar flux density, sky radiance and surface albedo on line of sight contrast transmission and thus smoke screen length are shown in Table 1.

The results here apply to a large area fog oil smoke screen and were obtained using the radiative transfer modification to COMBIC and referred to here as COMBIC-RT. Cases were run for morning

| | Surface Albedo = 0.2 | | | Surface Albedo = 0.5 | | |
|---|---|---|---|---|---|---|
| Transmission Threshold (%) | Early Morning Scenario | Late Afternoon Scenario | Normal COMBIC | Early Morning Scenario | Late Afternoon Scenario | Normal COMBIC |
| 10 % | 50 | 50 | 30 | 40 | 30 | 30 |
| 20 % | 110 | 80 | 40 | 60 | 50 | 40 |
| 30 % | 230 | 110 | 60 | 100 | 80 | 60 |
| 40 % | 400 | 140 | 90 | 150 | 100 | 90 |

**Table 1. Length of Cloud (m) for Contrast Transmission Thresholds (%)**

and afternoon scenarios and for two surface albedos indicative of vegetation (Case 1) and patchy snow (Case 2). The sun is in front of the observer in the morning and behind the observer in the afternoon. This is to demonstrate the importance of computing path radiance in determining the effectiveness of smoke clouds. For Case 1, the length of a cloud defined by transmission threshold of 10% showed no increase between the early morning or late afternoon scenarios, however, if the transmission threshold is set to be 20%, the length of the cloud increased significantly from 80 meters to 110 meters. Note, that normal COMBIC would have computed a length of 40 meters. So, we are seeing an increase of cloud length by a factor of two. For Case 2, the changes are smaller but still significant, showing an increase from 30 to 40 meters for transmission threshold of 10% and from 50 to 60 meters for transmission threshold of 20%. Other findings detailed in the main report also show effects of the solar angle with the largest effects occurring for those cases of forward scattering with the sun generally to the front of the observer and being more pronounced for thin optical depths. The effect of contrast transmission on the LER is difficult to access and our results are somewhat ambiguous, at least at first glance. Results do show that using COMBIC-RT to incorporate contrast transmission can be important in scenarios where the battle is east-west oriented and visual sensors are prevalent as was the case in past studies. However, in our study no scenario was found that was primarily oriented east-west and this is a trademark of today's modern, somewhat more stochastic, battlefield that has engagements over all directions and thus no dominant fixed orientation between the forces. Also, on the modern battlefield and in CASTFOREM, if a visual sensor is defeated, the model goes to another sensor (if available) operating in a different waveband. Most blue systems and many red systems have more than one sensor thus mitigating any adverse effects on visual systems.

d. MMW Sensors: In other cases, techniques that account for modern millimeter wave (MMW) obscurants were used to determine electromagnetic properties such as the ensemble averaged extinction, absorption, and scattering and mechanical properties such as fall velocity and angular orientation of the obscurant particles when released into the turbulent atmospheric boundary layer. Tables of mass extinction coefficient for a MMW obscurant were created for turbulent level, incident angle and vertical, horizontal and no polarization. These tables show that the obscurant extinction efficiency can vary by a factor of three depending upon the level of turbulence and type of polarization. A smaller extinction means a less effective obscurant cloud. The standard COMBIC uses a single mass extinction coefficient. In our study, this coefficient is higher than the value computed by COMBIC-PMW when a stable atmosphere, incident angle and polarization are modeled. Using the single coefficient in CASTFOREM has the result of erroneously increasing the effectiveness of the obscurant. When COMBIC-PMW is used in the runs, the mass extinction coefficient is lower, the obscurant cloud is less effective and the number of kills of a U.S. MMW munition increase by 8%. The decreased effectiveness of this MMW obscurant causes the effective kill range of this MMW munition to increase by 250-500 meters when the effects of turbulence, polarization and incident angle on extinction are modeled. The number of kills occurring at a given range can vary substantially between COMBIC and COMBIC-PMW for intermediate ranges ( 4000-6000 meters). The effect is less pronounced at higher ranges. This study also showed that polarization, not modeled in the standard CASTFOREM, is also very important. MMW radars can operate at different polarization, though this is not modeled in CASTFOREM. It is recommended that COMBIC-PMW be included into CASTFOREM and due consideration be given to playing polarization.

**Environmental Effects for Synthetic Test and Training Assessment Ranges (E2STTAR)**

Objective: The Synthetic Test and Training Assessment Range (STTAR) and Joint Advanced Distributed Simulation integrates live play and constructive simulations for testing, system evaluation and training. The Combat STTAR (CSTTAR), is joint project between the Test and Evaluation Command (TECOM), TRADOC, other Army organizations, and the Navy. The objective of CSTTAR is to infuse virtual intelligence assets into live training at the National Training Center (NTC). In order to do this effectively, it is necessary to include environmental effects such as smoke and dust. This joint effort between TECOM and ARL incorporates a smoke and dust model into

CSTTAR which satisfies the requirements to run near real-time and still provides sufficient fidelity for agreement with actual conditions on the live field at the NTC.

Status: ARL has improved methods for visualizing smoke in virtual environments. This was done by calculating smoke particle densities from the COMBIC model, the DoD de facto smoke model in EOSAEL, and used in the Synthetic Theater Of War - Synthetic Environment (STOW-SE) program. ARL represented the smoke puffs as a single three dimensional ellipsoidal surfaces; plumes where then represented as a series of ellipsoids making up the column of the plume. A fractal algorithm is subsequently applied to the surfaces of the ellipsoids allowing for natural appearing variation in the smoke field over time. This produces a high definition smoke cloud for close ranges, and a courser smoke cloud for long range observation. In addition the appearance of the ellipsoids varies with viewing angle and also allows for simulating the billowing of smoke. The use of three dimensional surfaces extends the two dimensional billboard techniques used in STOW-SE and provides improved visualization, both from outside the smoke plume looking through it and inside of it looking out. The end result is a smoke cloud that grows, detaches, drifts downwind from the source and finally dissipates

TECOM is currently working in parallel on different aspects of smoke insertion into CSTTAR. The first two address different visualization processes within CSTTAR. First is the generation of synthetic UAV imagery, which is used by the intelligence staffs and commanders participating in the training exercises. The second is the exercise management displays (stealth viewer) used by controllers during the exercise, and also for mission playback and debriefing after the exercise is completed. The UAV imagery is generated using Silicon Graphic's Performer software directly, while the exercise control imagery is based on third-party visualization software which indirectly uses Performer. In order to prevent confusion and provide consistent training, it is important that the UAV and exercise control visualizations provide the same visualization effects.

Initial examination by TECOM and ARL suggest that the COMBIC smoke will give excellent results when a small to moderate number of smoke plumes are generated. However, there will be exercises in which a large number of smoke plumes are needed, in which case the frame rate, when using COMBIC may slow to an unacceptable point. It may be possible to generate the plumes using the Performer built-in smoke utilities without loss of frame rate, but, again, these plumes produce unrealistic effects, depending on meteorological conditions and the requirements of a given exercise. It will remain to try various combinations in several CSTTAR exercises and get feedback from the exercise participants. A preliminary, rough estimate is that the performance will be excellent about 25% of the time, acceptable about 50% of the time, and unacceptable about 25% of the time.

**The Modeling of the Ground State in Winter Environments (GSWE)**

Objective: Cold environments can have drastic effects on Army operations. Current available Army models and simulations have almost no ability to replicate these effects. An inaccurate forecast, or no forecast at all, of the impact of cold environments on Army operations can have a negative effect on training, resulting in inaccurate planning, faulty analysis and subsequent failure of Army operations. The objective is to address the issue of predicting the state of the ground (surface temperature, snow cover, snow melt, and freeze/thaw depths) by utilizing CRREL's SNTHERM energy balance model. The methodology will investigate the sensitivity of the ground state to different flux model initializations, including a semi-empirical model, a plane parallel model, and ARL's AIM

(Atmospheric Illumination Module). Model runs for two locations (Grayling and Yuma), three seasons (spring, fall, and winter), and three sky states (clear, partly cloudy and cloudy) using the three flux model initializations and measured data will be made. The results will be inter-compared, including a comparison with measured ground state information.

Products/Deliverables: The effect of different solar and IR model fluxes in defining the state of the ground will be evaluated. This information will be of value in determining flux model fidelity necessary for high fidelity Synthetic Scene Generation Models. Deliverables will include source code (for models not available via electronic means) and user's manual along with a CRREL/ARL Technical Report. Estimated completion date is Sept '98.

## OTHER ARMY EFFORTS

**The Battlescale Forecast Model** (Roadmap related area - Weather Forecasts)

ARL's Battlescale Forecast Model (BFM) is the Army's mesoscale model and, as such, is a proposed DE standard. BFM is a meteorological forecasting model that is used primarily to obtain 4-dimensional meteorological field parameters (e.g. , winds, temperature, moisture, cloud, turbulence parameters, etc.) over complex terrain. The BFM is currently resident on the Army's fielded IMETS. The strength of the BFM comes from the high resolution of the model (10 km) and its ability to incorporate terrain effects. This gives the forecaster in the field a quick understanding of the effects the local battlefield terrain will have on the weather.

The BFM is a hydrostatic, quasi-Boussinesq, 16 layer mesoscale model is initialized with real time data and forecasted results from a synoptic scale model. It consists of several elements including a terrain elevation data production program, a three dimensional data analysis program of input data for model initialization and data assimilation, and a prognostic mesoscale model, called the Higher Order Turbulence Model of Atmospheric Circulation (HOTMAC). As part of BFM model output, interpolation programs for horizontal and vertical displays at desired heights and grid locations, graphical user interfaces for data input, execution, and display of the meteorological forecast are provided. A map background server to ease visualization of execution and forecast field display, and a series of algorithms in the Atmospheric Sounding Program to forecast visibility, clouds, icing, turbulence, etc. are also available.

As a future upgrade to the BFM a model based on the University of Wisconsin's Non-Hydrostatic Modeling System (UW-NMS) is being examined. The UW-NMS model can utilize several terrain following vertical coordinate systems to solve the equations of mass, momentum and energy. The model contains detailed microphysics and its non-hydrostatic nature allows solutions at higher grid scale resolutions. The formulation of the model permits it to perform as a Large Eddy Simulation, thus yielding a more detailed definition of atmospheric and boundary layer turbulence. The UW-NMS is currently used by the Battlefield Environment Division for special studies requiring high resolution, time dependent meteorological data (e.g. atmospheric transport and diffusion of hazardous materials) and by the University of Wisconsin as an operational forecast model.

**Weather and Atmospheric Visualization Effects for Simulation** (Related roadmap area - Illumination/Cloud & Shadows)

The Weather and Atmospheric Visualization Effects for Simulation (WAVES) suite of models, being developed by ARL, predicts illumination and radiance information for a three-dimensionally variable atmosphere as a function of cloud type and amount, including partly cloudy skies at visual and infrared wavelengths. It also predicts electro-optical propagation effects for horizontal and slant paths through the natural atmosphere. WAVES output illumination and propagation effects are critical to accurate target acquisition and scene generation. WAVES computations include direct solar/lunar radiation, multiply scattered solar/lunar radiation, optical turbulence, and forward scattering due to atmospheric aerosols.

WAVES was conceived and developed under a series of Tri-Service Programs to develop complete modeling and simulation of visualization and imaging of the atmospheric environment. WAVES beginnings may be traced to the Smart Weapons Operability Enhancement (SWOE) program, through the Target Acquisition Modeling Improvement Program (TAMIP), the DMSO Environmental Effects for Distributed Interactive Simulation (E2DIS) program, and is now under the DSMO Executive Agent for Space and Atmospheres program "Radiometric Validation of the Cloud Scene Simulation Model (CSSM) and Boundary Layer Illumination and Radiative Balance Model (BLIRB)" where it is currently integrated and evaluated.

The WAVES suite of models, (radiative transfer model BLIRB, atmospheric optical turbulence model ATMOS, geometric radiance interpreter module VIEW, and the scene modifier module PIXELMOD) are integrated together to provide either modifications to existing scenes for real time computer image generation or radiance values for a defined scenario. WAVES computes tables of solar/lunar multiply scattered radiation under varying atmospheric conditions which includes calculations for Rayleigh scattering, scattering by background aerosols, and scattering from inhomogeneous clouds and partly cloudy skies. WAVES does not attempt to impose any particular rendering method, but does provide the 2 and 3-D data to support a wide range of possible user implementations. It is expected that WAVES will become a standard environment for radiative transfer calculations for Army usage within the next three to five years.

**The High Resolution Wind Model** (Related roadmap area - Terrain Coupled Winds)

The ARL developed High Resolution Wind (HRW) model is a two-dimensional, diagnostic, time independent model which computes horizontal fields of the wind components, the mean wind velocity, friction velocity, potential temperature, the Richardson number and the Power Law exponent. The model typically simulates the flow field over a grided area of some 5 km by 7 km with a spatial resolution of 100 m. Model initialization requires a single surface value of wind speed and direction, temperature and a corresponding radiosonde type measurement. The radiosonde data is used to provide an estimate of the bulk atmospheric buoyancy. This estimate is computed by the model by applying the initial single point values at each grid point in the computational array along with digitized terrain elevation. Simulation results are obtained by direct variational relaxation of the wind and temperature fields in the surface layer. The solution is reached when the internal constraint forces imposed by the warped terrain surface, thermal structure, and requirements for flow continuity are minimized. The procedure uses Gauss' Principle of Least Constraints which requires these forces to be minimized in order to satisfy the equations of motion. When applied to the surface layer, this procedure requires the use of empirical wind and temperature profiles. The computational domain size can range from 2km by 2km to 20 km by 20 km with grid resolutions of 40 m to 400 m respectively. Note that HRW is usually run for a nominal 5 km by 5 km area and a vertical thickness of the computational layer 1/10th the magnitude of the grid size. This layer thickness can, however, vary from 2 to 50 m.

**Scanning Fast Field Program** (Related roadmap area - Acoustics)

This ARL developed model is an atmospheric acoustics propagation model incorporating many of the effects of the environment on the sound field such as geometrical spreading, refraction, diffraction, molecular absorption, and complex ground impedance. It is based on the Fast Field Program (FFP) with the added ability to scan multiple azimuths to predict the propagation conditions about the location of a sensor. FFP is a one-way solution to the acoustic-wave equation originally developed for underwater sound propagation predictions. The Scanning Fast Field Program (SCAFFIP) provides range estimations from the sensor or target for signal-noise of -10, -5, 0, and 10 dB (re: 20mPa) with azimuth for a given geometry, sound level of target at a given frequency, and meteorological profile. The meteorological profile and geometry provide the model the ability to calculate the sound speed profile. The geometry profile is required because the angular dependence of the sound speed on the wind direction is relative to the direction of propagation. This model works well over a flat-earth and a non-turbulent atmosphere. In the near future this model will be added to EOSAEL.

**VLSTRAK, D2PC and TADSIM** (Related roadmap area - Transport and Diffusion/Chemical and Biological)

The US Army supports three Transport and Diffusion modeling efforts. The approved operational models supported by the US Army Chemical and Biological Command (CBDCOM) are a Gaussian puff model, VLSTRACK (Vapor, Liquid, Solid Tracking) and D2PC (2-Dimensional T&D for Personal Computers). The D2PC model is the only model certified by the US Army Chemical and Nuclear Agency (USANCA) for operational use. Both models use climatology and/or rudimentary meteorological parameterizations to compute the trajectory of a toxic cloud. VLSTRACK and D2PC are both easy-to-use programs that provide rapid results on PC type platforms. The primary causes for error in military applications of transport and diffusion (T&D) models are inadequate source descriptions and the treatment of the spatial and temporal variability of dispersion. Data sets available for validation of dispersion models rarely contain adequate source information. The third model, ARL's Transport And Diffusion Simulator (TADSIM), is a suite of models which embodies a methodology to mitigate these problems and has been specifically designed to address the space and time variability issue.

VLSTRACK facilitates model initiation and output interpretation through its Graphical User Interface. However the model is restricted due to its limited source term flexibility, the lack of terrain influenced meteorology, and its treatment of dispersion, which is tied to a limited categorization scheme. The source term selection is based on a library of delivery systems and agents. Inherent randomness in the mean flow, which in reality is a larger scale dispersion effect influenced by terrain, is driven by a random number generated functional variation to the transport. VLSTRACK comparisons with field trial data do not always agree. D2PC uses a single wind and turbulence parameter for the entire simulation domain and time period. Thus, this model can only be considered valid for flat terrain, small spatial domains and short time intervals.

TADSIM consists of a transport driver utilizing 2-D wind fields at variable resolution and user-selectable codes for traditional Gaussian and non-Gaussian dispersion for both horizontal and vertical cloud spread. This suite of models is comprised of HRW (see 3.2.2.3) , AIRSIM, a large eddy simulation (LES) model for airflow over terrain, AIRFLOS, a LES model for airflow over structures, and ABCSIM, an atmospheric chemical/biological simulation for T&D of the agent cloud. These dispersion codes are designed to be specific to the local meteorological and terrain conditions rather than using generalized classification techniques. TADSIM is in the verification/validation stage of development and employs a unique method for handling vertical diffusion called transilient turbulence. This technique is particularly suited to the treatment of dispersion in unstable atmospheres. The current version of TADSIM has been verified and has undergone limited validation.

**The Electro-Optical Systems Atmospheric Effects Library** (Related roadmap area - EOSAEL)

The Electro-Optical Systems Atmospheric Effects Library (EOSAEL), developed by ARL began its development in 1978 and is currently considered a mature code. EOSAEL contains 22 computer modules that can be separated into eight generic classes: (1) atmospheric transmission and radiance (LOWTRAN, UVTRAN, and NMMW), (2) laser propagation (LZTRAN and NOVAE), (3) tactical decision aids (KWIK, GRNADE, COPTER, and MPLUME), (4) battlefield aerosols (COMBIC and FITTE), (5) natural aerosols (XSCALE and CLIMAT), (6) target acquisition (TARGAC), (7) radiative transfer (OVRCST, ILUMA, FASCAT, GSCAT, LASS, REFRAC, NBSCAT, and BITS) and (8) phase function and Mie code support modules. The philosophy underlying the development of EOSAEL has been to include modules that give reasonably accurate results with the minimum in computer time for conditions that may be expected on the battlefield. The latest version of EOSAEL is available to approved users through the Test and Evaluation Community Network Bulletin Board System (TECNET); more information concerning EOSAEL may be found at the world wide web site URL address "http://www.eosael.com".

**The Master Environmental Library** (Related roadmap area - MEL)

The MEL project is a multi-year project funded by the DMSO Modeling and Simulation Resource Repository (MSRR) and the DMSO Executive Agents for Environment (Atmosphere and Space, Oceans, and Terrain) to provide the basis for promoting joint service standards and capabilities for M&S to represent the natural environment in which all DOD modeling and simulation users need to operate. The specific project objectives are 1) to provide a library structure for the M&S community to access the atmospheric/space, oceanic, and terrain environmental data which are available to the warfighters now and in the near future; and 2) to make physically consistent data sets available for authoritative environmental representations. MEL is an Internet based data discovery and retrieval system providing access to geographically distributed oceanographic, meteorological, terrain, and near space databases. Orders for data are transferred to a regional site via electronic mail and processed by the MEL regional site software (RSS). This software is customizable and performs the functions of order parsing, access control, scheduling, data extraction, formatting, compression, encryption, delivery and notification. Data can be delivered via ftp, email, put on tape and mailed or it can be picked up via anonymous ftp at the regional site. Soon functionality for real-time HTTP ordering and delivery will be added for data sets that are not too large.

The participants of the MEL project include operational and R&D agencies from the Air Force, Army, Navy, and DMA. More information can be retrieved from the MEL homepage on the world wide web at http://www-mel.nrlmry.navy.mil

**SWOE and CREATION** (Related roadmap area - Synthetic Backgrounds)

The physics based Joint Test & Evaluation Smart Weapons Operability Enhancement (JT&E SWOE) is a synthetic scene generator. SWOE models can produce synthetic scenes for user-specified spectral regions in the visible, infrared, and MMW regions. The SWOE thermal models consist of a soil/snow, vegetation, canopy, and a single 3-dimensional tree model. The thermal models consider the exchange of energy via conduction, convection, radiation, evapotranspiration, and the mass flux of precipitation. The SWOE radiance models consider emitted, primary and secondary reflections, bi-directional effects, and the atmospheric attenuation. The SWOE models are used to generate selected scenes for proposed generic validation procedures. SWOE also has an associated high spatial resolution measured database, including meteorological information, taken diurnally over four seasons; the measured locations, Grayling, MI and Yuma, AZ, represent European and SW Asian analogs.

The ARL developed CREATION model is also a synthetic scene generator. CREATION is a 3-dimensional multispectral high-resolution scene generation program which has the capability to simulate infrared and visible, static and dynamic synthetic images of many diverse real world environments. 3-D geometry inputs to CREATION start from digital maps obtained from the Defense Mapping Agency which have been interpolated to higher resolution of approximately one to two meters. The associated high-resolution feature map is developed from high-resolution aerial pictures and road maps to define the location of trees, grass, roads, lakes, etc. The thermal signature of background components are predicted with the Interim Thermal Model (developed under the SWOE program, using the Waterways Experimental Station's background prediction model and the SNTHERM model from CRREL); texture variations are also applied to the background components to enhance scene realism. 3-D target geometry can be placed into the 3-D background map with 6 degrees of freedom. The target signatures are derived from either the PRISM or GT-SIG signature prediction models. The sensor and target can be varied within these 6 degrees of freedom to allow a multitude of viewing aspects. Atmospheric and sensor effects can also be applied to generate specific meteorological conditions and sensor system output.

**PRIORITIES**

Dr. Anita Jones, Director, Defense Research and Engineering, June 1993 - May 1997, in a memorandum dated 21 Jan 94, subject: Priorities and Objectives, directed that DMSO objectives include authoritative representations, such as weather and smoke, which can be validated for selected purposes, maintained, promulgated and shared by multiple users. ARL's Information Science and Technology Directorate, Battlefield Environment Division, is the Army's lead coordinating agency in the area of Dynamic Environments, and is tasked with the responsibility of advancing the above mentioned priorities and objectives in this area. Priorities may be located in the road map throughout the text of this document.

**Annual Standards Category Report for FY98**

# FUNCTIONAL DESCRIPTION OF THE BATTLESPACE

## INTRODUCTION

The Functional Description of the Battlespace (FDB) offers the potential for increased code re-use, maintainability, and ease of developing and documenting current and future simulations. The Army has developed the FDB since 1994 as a means to enable simulation users to describe Army functionalities on the spectrum of conflict for all echelons. The Working Group consisted of representatives of TRADOC, STRICOM and industry. The FDB contribution to the SCC program focuses on the simulation development process that are independent of the simulation application. Initial implementation of the proposed policy would be focused on developing guidelines and objects for four new simulation developments -- WARSIM 2000, JSIMS, JWARS, , OneSAF, and other programs. The FDB categories and their definitions will be based upon Army standards for databases, models and algorithms from the identification of requirements to the storage of validated models and information for simulations..

## STANDARDS CATEGORY DEFINITION

The Functional Description of the Battlespace (FDB) Standards Category is defined as the process that develops simulation and research database configuration and management tools consistent in their representation of Army Battlespace Domain activities and functions, understood by the M&S community, and interoperable at levels allowed by their model environment.

## STANDARDS REQUIREMENTS

The FDB Standards Category will address the following:

- Development of definitions of simulation development methods for Army use;
- Development of policy and procedures for managing Army repository data, models, and algorithms for the simulation developers and users
- Formation of liaisons between major Army simulation programs and other Standard Categories to encourage use, updates, and expansion of object classes; and
- Explore methods of gathering, sharing and storing database models, data and algorithms for building new models, conducting new processes and establishing standards for reuse on future development programs.

## ACCOMPLISHMENTS AND ASSESSMENT

The FDB SCC Team has sought to involve several other SCCs in sharing resources and ideas to promulgate standards development in the Army modeling and simulation community. Meetings with all domain representatives have shown the importance of sharing capabilities and functionality. The team has met with the Logistics SCC to discuss integration of Logistics algorithms on the FDB. Further discussions with the Intelligence SCC representatives from NGIC and AMSAA have been fruitful. AMSAA intends to utilize the FDB's Object Repository for its own efforts. Working closely with DMSO, JSIMS/JWARS, the FDB SCC Team has found and shared common interests with the MSRR, JCMMS and DMSO's Conceptual Model of the Mission Space (CMMS). Attendance at the AMSO Army M&S Standards Workshop on 5-8 May permitted an in-depth review of the FDB SCC's goals and objectives for the next two years. Discussions with other SCCs provided key information for all parties concerned to see where collaboration could bring better adoptive standards for the Army. The FDB SCC Team also presented an overview of the FDB to the workshop. The goal is to promote the development of a common FDB architecture, incorporate identified Army standard algorithms/data, and facilitate model and code reuse.

## PRIORITIES FOR NEXT YEAR

Continuing with the current WARSIM 2000 and JSIMS requirements, the FDB SCC Team will develop new methods which are accessible and useful to other SCCs to share their data, models and algorithms. Further collaborative efforts are also planned to enhance modeling and simulation developers. To continue addressing the FDB SC charter, an AMIP proposal will be nominated to:

- Develop a "tailorable" FDB for all SCCs based on their requirements for data, model and algorithms collection, production and storage.
- Demonstrate the feasibility of using the FDB to maintain and develop scenario data and information for building simulation scenarios.
- Examine linkages and collaborative efforts in the DoD Modeling and Simulation community.

**Annual Standards Category Report for FY98**

# LOGISTICS

## STANDARDS CATEGORY DEFINITION

This standards category includes the objects, algorithms, data and processes which model or simulate the initial provisioning, supply, resupply, stockage, facilities, maintenance and sparing of the ten supply classes, and combat service support (CSS) services provided to and in the field. Army standardization requirements must address M&S support for CSS functions to and in the field.

## STANDARDS REQUIREMENTS

The following is a prioritization of the CSS functions that the Working Group deemed appropriate

-

1. Supply - Class III (Bulk)
2. Supply - Class V
3. Supply - Class VII
4. Supply - Class IX
5. Personnel
6. Supply - Class I (and water)
7. Maintenance
8. Medical
9. Services
10. Supply - Classes II, III (Pkg), & IV
11. Finance
12. Stockage
13. Supply - Classes VI and X
14. Facilities

## ACCOMPLISHMENTS AND ASSESSMENT

During the past year, the Working Groups accomplishments were as follows:

1. On 31 January 1996, the Contractor (Vector Research, Incorporated) completed the second draft of the standard algorithms, delivered the required documentation, and completed the contract.

2. The following is a list of the CSS functional areas for which supply algorithms have been identified and cataloged:

- Class I (Subsistence) and Water
- Class III (Bulk and Packaged POL)
- Class V (Ammunition)
- Class VII (Major End Items)
- Class IX (Repair Parts)
- Maintenance
- Class II (General Supplies)
- Class IV (Construction Materials)
- Class VI (Personal Demand Items)
- Class VIII (Medical Supply - Including Blood)
- Stockage (All Classes)
- Medical (Including Patient Rates, Evacuation Rates, and Hospital Bed Requirements.
- Personnel

*Logistics*

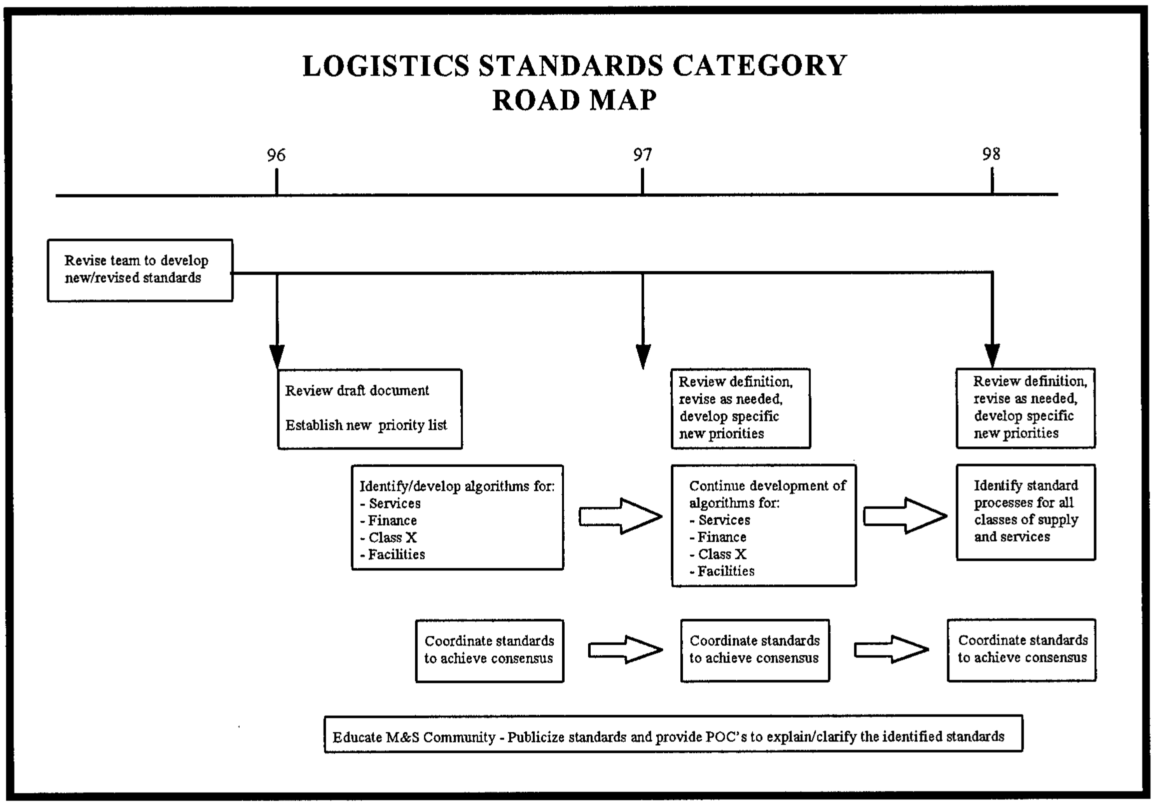
1. The majority of the identified algorithms were obtained from three on-going Army programs, the Supply Usage Requirement Estimator (SURE), the Operations Logistics Planner (OPLOGPLN), and the Combat Service Support Control System (CSSCS).

2. The document, Second Draft of Standards, is being reviewed by the CASCOM and will be sent to Working Group members for their review. Review should be completed by 31 August 1996.

## PRIORITIES FOR NEXT YEAR

1. Continued development of the above algorithms, and the identification and cataloging of algorithms in the functional areas of Services, Finance, Class X and Facilities.
2. Long term priorities is the identification of standard processes which model or simulate CSS functions to and in the field.

## ROAD MAP



## Annual Standards Category Report for FY98

## MOBILIZATION/DEMOBILIZATION

### PURPOSE

This Standards Category Coordinator (SCC) Annual Report provides a status of standardization in the standards category of Strategic Activities - Mobilization/Demobilization (MOB/DEMOB). This report provides updates of significant MOB/DEMOB efforts for FY 97 that were both influenced by the Army Model Improvement Program (AMIP) and may impact the AMIP program in the future. The report presents and prioritizes AMIP submissions in the above category for FY 98 and will serve as a permanent record of the status of standardization within the category.

### STANDARDS CATEGORY DEFINITION

MOBILIZATION: Includes the algorithms, objects and unique modeling techniques needed to accurately portray preparation of forces for military operations to include:

Active Units: Unit notification of deployment, unit readiness enhancements (cross-leveling personnel/equipment, personnel soldier readiness processing (SRP), predeployment training.

Reserve Units: Units receiving Alert/Mobilization Orders, Home Station processing to include cross-leveling, movement to Mobilization Station (MS)/Power Projection Platform (PPP)/Power Support Platform (PSP), unit readiness enhancements (personnel/equipment, SRP, training validation), additional unit training (i.e., E-Brigades to Ft. Irwin).

Active Duty Individuals: Individual receiving a reassignment order to an installation to be assigned to a deploying unit to fill shortages or to a CONUS Replacement Center (CRC) as an individual filler or casualty replacement for an OCONUS theater.

Mobilization of Reserve Component Individuals (Individual Ready Reserves, Individual Mobilization Augmentees), development of individual requirements, selection and notification of individuals , movement of Reserve Component (RC) individuals to TRADOC for skill validation/skill refresher training, further assignment/movement to a CONUS installation/assignment/movement to CRC for OCONUS deployment.

The expansion of CONUS/OCONUS installation support facilities to include activation of an installations' MOBTDA.

Preparation for movement to air port of embarkation (APOE)/sea port of embarkation (SPOE), both personnel and equipment, both unit and nonunit. (Note: movement from PPP/PSP to air port of debarkation (APOD)/sea port of debarkation (SPOD) falls under deployment/redeployment category.)

Acquisition, Processing, and deployment of Civilian Personnel (to include Department of the Army Civilians (DAC), contractors and other support personnel (e.g., Red Cross) to meet new and increased Army requirements.

Surge and expansion of the industrial base.

DEMOBILIZATION: Beginning at the Demobilization Station or a CRC to conduct:

Department of the Army (DA) determination of RC unit/individual requirement to remain on active duty.

RC Units - Demobilization Station processing to include installation support requirements, equipment processing, personnel transition (reverse SRP), issuing demobilization orders, movement of personnel and equipment to Home Station (HS) (separately/together), HS demobilization processing/activities, release from active duty (REFRAD).

RC Individuals - Arrival at CRC, CRC installation support requirements, personnel and individual equipment deprocessing (reverse SRP), movement to permanent address, REFRAD.

Reassignment of Active Duty/RC Active Guard Reserve (AGR) individuals from assigned units to original units.

## STANDARDS REQUIREMENTS

- Standardize algorithms, objects and techniques for modeling mobilization and demobilization
- Provide linkage of mobilization/demobilization models and simulations to real time databases
- Create High Level Architecture (HLA) Federation with strategic deployment and transportation modeling objects and algorithms

## ACCOMPLISHMENTS AND ASSESSMENT

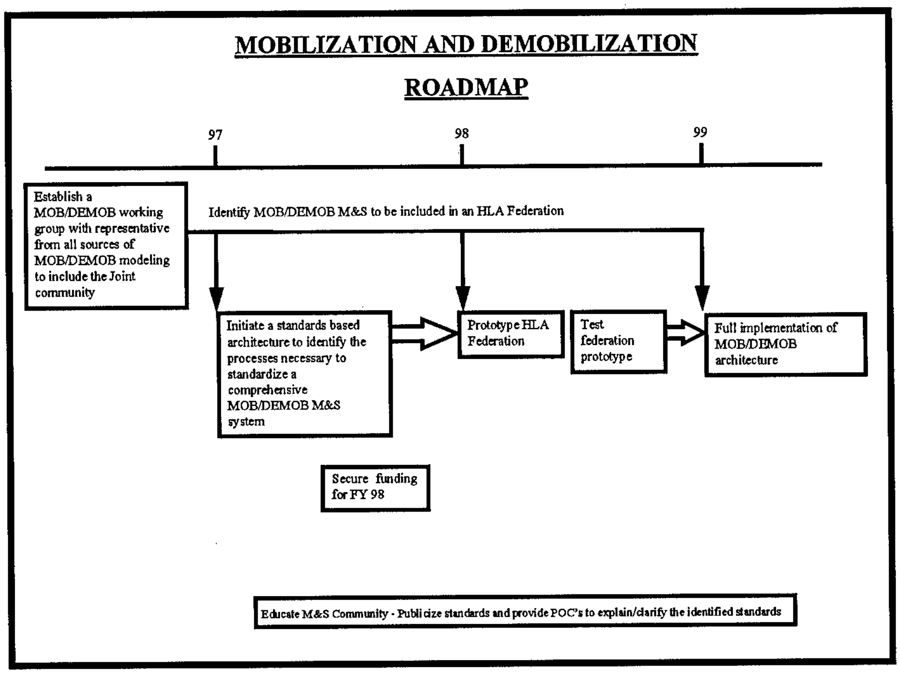
- The Mobilization Capabilities Evaluation Model (MOBCEM), a model under development at Concepts Analysis Agency (CAA), models mobilization from HS to Port of Embarkation (POE). Phase I of three phases of development has been completed. Phase I included hardware and software purchases, design detail, and software implementation of the design. Funds are required for Phase II, which will include design and implementation of the mobilization processes which take place at training centers, CRCs, and POEs; documentation; automatic data preparation; HLA compliance; and training for analysts. Estimated funding required for Phase II is $605,000.
- FORSCOM continues development of the MADCAP Integration Management Initiative (MIMI) which allows operational planners to analyze availability of units for onward movement and collective load on mobilization stations in a variety of resource categories.

## PRIORITIES FOR NEXT YEAR

- MOBCEM:
  - ⇒ Initiate and finish MOBCEM Phase II - CRC (individual processing), Training, POE
  - ⇒ Initiate MOBCEM Phase III - Joint Processes
  - ⇒ Initiate MOBCEM Phase IV - Inclusion of Demobilization Processes
- SABRE: Artificial Intelligence (AI) Center to combine the functionality of FORSCOM's Single Army Battlefield Requirements Evaluator (SABRE) and CAA's Matching Army Resources to Yearly Requirements (MARTYR)systems, transition from Lisp to C++, and transport the new system to the Global Command and Control System (GCCS).

## ROAD MAP

1. Establish a MOB/DEMOB working group with representatives from all sources of MOB/DEMOB modeling to include the Joint community - 1997.
2. Initiate a standards-based architecture to identify the processes necessary to standardize a comprehensive MOB/DEMOB model and simulation (M&S) system - 1997,
3. Identify MOB/DEMOB M&S to be included in an HLA Federation - 1997.
4. Secure funding for FY 98 - 1997.
5. Prototype HLA Federation - 1998.
6. Test federation prototype - 1998.
7. Full implementation of MOB/DEMOB architecture - 1999-2000.




## PROPOSALS

AMIP proposals for the Mobilization/Demobilization:

1. MOBCEM - Mobilization/Demobilization model.
2. SABRE/MARTYR - Increase and standardize functionality.

*Mobilization/Demobilization*

## Annual Standards Category Report for FY98

## MOVE

### STANDARDS CATEGORY DEFINITION

The Move category addresses the objects, algorithms, data and techniques necessary to replicate activities that influence land force platform and personnel movement (ground, air, and water). It also addresses mobility and countermobility as engineer functions, suppression (as a mobility degrader), formations and dispersion.

### STANDARDS REQUIREMENTS

Current Army standardization requirements include:

1. Land force platform and personnel movement
2. Mobility and countermobility as engineer functions
3. Suppression effects on movement
4. Dispersion and formations

### ACCOMPLISHMENTS AND ASSESSMENT

In support of Objective 3 (Chapter 4, Army M&S Master Plan, May 1995) - Provide authoritative representations of systems, the following AMIP-funded studies have been completed:

1. Investigation of Movement Representation in Selected Constructive Models and Simulations, draft 1996, AMSAA.
2. Investigation of Movement Representation in Selected Virtual Models and Simulations, draft 1997, WES.

The following AMIP-funded study is on-going at WES and due for completion by the end of FY97:

1. Assessment of Mobility Performance within CCTT SAFOR.

### ACCOMPLISHMENTS

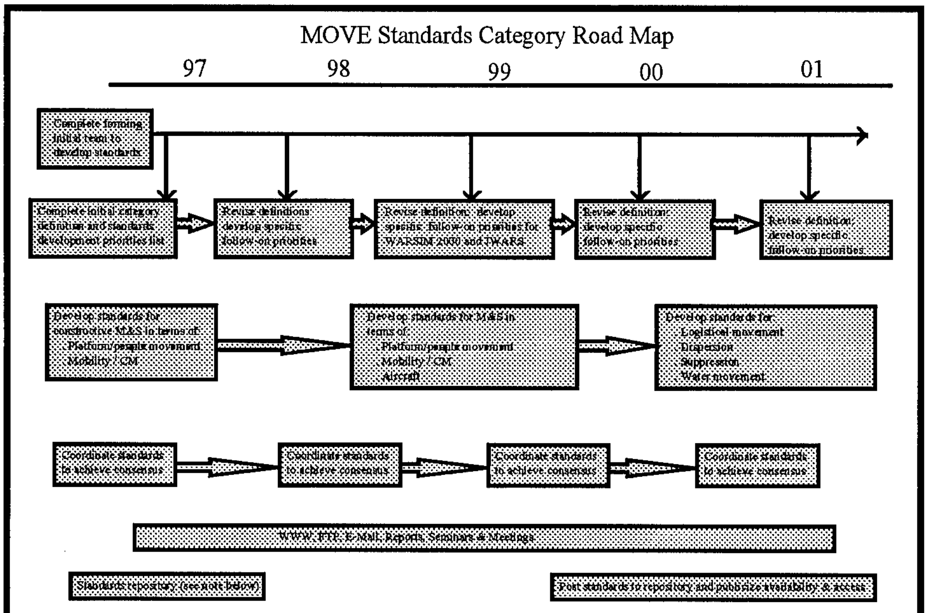
- Recommended the NATO Reference Mobility Model, Version II, as a standard for representation of ground movement for single ground vehicles.
- Findings from the FY96 study as well as emerging results from the current study (listed above) were presented at the 65th Military Operations Research Society Symposium. During his recent visit to WES, Mr. Walt Hollis was briefed on the status of the current study.
- The Move category submitted a summary of movement representations in current M&S as well as recommendations for standards in answer to the tasking by Mr. John Riente in support of JWARS.
- Move team members participated in the M&S Workshop in May and, based on requirements identified by senior Army leaders, revised the Move standards category road map (Para 5) to include priorities for WARSIM 2000 and JWARS/JSIM. Additionally, based on input from other standards categories and known available modeling for engineer mobility and

countermobility, established a prioritized objective listing for the Move standards category.

## PRIORITIES FOR NEXT YEAR

A report documenting the findings of the FY97 AMIP study will be produced. Emphasis will be placed on M&S standards in terms of platform/people movement, engineer mobility/countermobility, and aircraft movement with specific priorities placed on support for WARSIM 2000 and JWARS.

## ROAD MAP




Note: The NRMM-II, para 4, is the Army standard model for predicting the performance of vehicles operating on-off road and is managed jointly by WES and TARDEC. The NRMM-II is managed to keep abreast of emerging vehicle technologies, terrain descriptions and computational technologies. WES serves as the repository of NRMM-II for modeling and simulation applications.

## AMIP PROPOSALS

In accordance with Tab 2, Appendix B, The Army M&S Master Plan, May 1995, the top three Move standards category proposals for consideration for FY98 funding are submitted:

1. *Mobility/Countermobility Representation for WARSIM 2000/JWARS.* The objective is to provide engineer mobility/countermobility representation adequate to meet requirements in WARSIM 2000/JWARS. Executing agency: WES

2. *Air Battle Algorithms*. The objective is to assess the adequacy of air battle algorithms in replicating required capabilities of aircraft systems in WARSIM2000. Executing agency: AMSAA/USAAVNC

3. *Verification and Validation Tool for Testing Vehicle and Dismounted Maneuver Performance and Baseline Analysis of Maneuver Capabilities in ModSAF.* The objective is to conduct a maneuver 'peelback', that is, a deliberate examination, of the model architecture supporting maneuver portrayal in ModSAF. Executing agency: USAES

**Annual Standards Category Report for FY98**

# OBJECT MANAGEMENT

## INTRODUCTION

Object-oriented programming offers the potential for increased code reuse, maintainability, and ease of developing entity-level simulations. Because of these benefits, the use of object oriented technologies will increase over time. In order to prevent duplication of effort and the development of incompatible models, objects will need to be managed. To address this issue the Deputy Undersecretary of the Army for Operations Research (DUSA-OR) established a working group in September 1996 to develop an Army object management policy. The Working Group consisted of representatives of AMSAA, AMSO, CAA, STRICOM, and TRAC. A proposed policy was developed and provided to the DUSA-OR in early 1997. This policy focused on the portions of the object-oriented simulation development process that are independent of the simulation development environment (i.e., defining object classes and object class attributes). Initial implementation of the proposed policy would be focused on developing guidelines and objects for four new simulation developments -- JWARS, WARSIM 2000, OneSAF, and COMBAT 21. The object classes will incorporate Army standard algorithms and data.

## STANDARDS CATEGORY DEFINITION

Object management is defined as the process that develops abstract object classes that are:

- Consistent in their representation of object attributes/methods,
- Understood by the M&S community, and
- Interoperable at levels allowed by their model environment.

## STANDARDS REQUIREMENTS

The Object Management Standards Category (OMSC) will address the following:

- Development of definitions of abstract object classes for Army use,
- Development of policy and procedures for managing Army objects,
- Formation of liaisons between major Army simulations and other Standard Categories to encourage use, updates, and expansion of object classes, and
- Exploration of methods for gathering, sharing and storing metadata about objects.

## ACCOMPLISHMENTS AND ASSESSMENT

The kick-off meeting of the newly formed Object Management Standards Category took place on 17 April 1997 at Aberdeen Proving Ground, MD. Representatives from AMSAA, AMSO, CAA, STRICOM, TRAC-FLVN, TRAC-MTRY, and TRAC-WSMR participated. The purpose of the meeting was to confirm category membership, review the DUSA-OR proposed object management policy, discuss the OMSC definition and requirements, and devise an approach addressing the objectives of the standards category. The initial thrust of the category lies with the AMSO-funded study being conducted by TRAC-MTRY to discover potential object models by a careful review of legacy and developmental simulations. These simulations include:

- CCTTSAF
- ARES
- JSIMS
- JWARS
- EAGLE
- ModSAF
- CASTFOREM
- JANUS
- WARSIM

Additionally, the effort will include a review of object repositories such as the Functional Descriptions of the Battlespace (FDB) and the Conceptual Model of the Mission Space (CMMS).

Attendance at the AMSO Army M&S Standards Workshop on 5-8 May allowed a more detailed review of the object structures TRAC-MTRY collected over the course of their effort. A special session was offered at the workshop to present the objectives, scope, and approach of the OMSC to representatives from the other categories. This provided an overview of the proposed Army object management policy, the OMSC approach in executing the policy, and the future interaction between the OMSC and other categories to define Army standards associated with object classes.

By the end of FY97, the Object Management Standards Category will have an initial set of draft object/classes for coordination with simulation developers. These object/classes will form the basis for future model development. The goal is to promote the development of a common architecture, incorporate identified Army standard algorithms/data, and facilitate object code reuse.

**PRIORITIES FOR NEXT YEAR**

Starting with the draft object class structures from the TRAC-MTRY study, FY98 will include coordination and refinement of the draft object class structures by the M&S community, primarily the M&S simulation developers. To continue addressing the OMSC charter, an AMIP proposal will be prepared to:

- Expand the draft object class structure based on coordination comments and recommendations from the TRAC-MTRY study,
- Correlate the object class attributes and behavior requirements with Army standard algorithms and data via the AMSO Army M&S Standards Categories,
- Explore and recommend repository and database format to store, disseminate, and update object classes for Army use, and
- Recommend a policy and documentation requirement for nominating objects for inclusion into the Army object database.

# Annual Standards Category Report for FY98

# SEMI-AUTOMATED FORCES (SAF)

## INTRODUCTION

During the past year strides have been made in the development of Semi-Automated Forces (SAF) software. Many of these accomplishments have been made without a significant, centralized infusion of resources to support SAF development. Within the Army, there has been a general recognition that a new architecture is necessary to support future SAF applications. TRADOC has taken steps to describe the necessary requirements that will define that architecture, and AMC is beginning the process of determining technical feasibility and affordability of a new SAF architecture.

The purpose of this report is to provide a short overview of these accomplishments and to set priorities for semi-automated forces for FY 98. The first section also reviews the priorities in the area of semi-automated forces (referred in last year's report as Computer Generated Forces) highlighted in the FY 96 Annual Report. Section 2 lists software infrastructure improvements in SAFs over the past year. Advancements in the technology of SAFs are reviewed in Section 3. Most prominent in this area is the emerging concept of OneSAF. This Army initiative may allow both a closed form (analytical) and human-in-the-loop (HITL) capability within the same simulation architecture. The final section provides a focus for FY 98. This section will include some thoughts on developing a single SAF for all domains, as well as improving the SAF capabilities within the legacy SAF systems.

## STANDARDS CATEGORY DEFINITION

For the purposes of this report Semi-Automated Forces will be defined as "Software integration that produces realistic entities in synthetic environments which interface appropriately with live, constructive, virtual and simulator entities, but which are generated, controlled and directed by computer software." (The FY 95 Army Model and Simulation Modernization Plan)

## STANDARDS REQUIREMENTS

Standardization objectives for SAF are outlined in the Army Model & Simulation Master Plan, and were expanded in the FY 95 assessment. These are shown below.

1. Develop SAF standards that are useful in all M&S domains, applicable to distributed simulations, representative from single entity to corps, and useful in a joint environment.
2. Minimize operator overhead for SAF.
3. Ensure structures and databases are modular and easily isolated.
4. Provide consistent representations for battlefield systems, and unit tactical/doctrinal behaviors in all SAFs.
5. Support the development of the High Level Architecture.

## FY 97 PRIORITIES AS DEFINED IN THE FY 96 ANNUAL REPORT

**HLA Compliance.** ModSAF is participating in a prototype HLA federation through its use in the Synthetic Theater of War - 97 (STOW-97) program. During this experiment, information will be gathered concerning the technical issues associated with ModSAF interoperability with aggregate level simulations through the HLA Run Time Infrastructure (RTI). In particular, ModSAF has included some key data structures and enhancements in its baselines that will provide most of the required HLA capabilities. Continued participation in HLA federations should be encouraged and continued to gather data concerning RTI performance as well as aggregation and disaggregation techniques. These lessons will serve the future WARSIM linkage to an entity level model.

**Consistent representations within ModSAF and CCTT SAF to enhance reuse and interoperability.** Consistent representations within SAFs will provide a basis for reuse and interoperability. During FY 96, TRAC implemented a group of BLUFOR CCTT SAF CISs in ModSAF. This implementation improved the quality of the associated behaviors in ModSAF, and this work should be continued and expanded to address the key CISs that serve as a basis for the opposing force behaviors.

**Improving the ModSAF battle environment.** The battlefield operating system in ModSAF is continually being enhanced, although many of the added capabilities have not been thoroughly verified and validated. Version 3.0 includes CS/CSS (engineering, transportation, maintenance, and supply), phenomenology (smoke, night, uniform atmospheric effect), STINGRAY, Crusader, and critical PTR fixes. The STOW-97 baseline, which has not yet been accepted for inclusion in the Army baseline, will include Global Coordinate System capabilities, Theater Missile Defense, CFOR fixes, and some rotary wing enhancements. Version 4.0 capabilities will depend on availability for funding for critical PTR fixes as well as intended domain usages.

**Improving SAFs for use in all modeling and simulation domains.** ModSAF has already been used in exercises such as STOW-Europe and STOW-97 to support training and military operations. ModSAF has also been used within the research, development, and acquisition domain to explore new doctrine, tactics, and force structure in the A2ATD and Stingray programs. However, much work remains to prepare ModSAF as a useful tool for analysis. For example, tools should be created for use in ModSAF that will facilitate data preparation and analysis. Also, the lack of traceability and repeatability of behaviors in model execution preclude ModSAF and CCTT SAF usage as the basis for statistical analysis.

### SAF TECHNOLOGY ENHANCEMENTS

**Standardization of behaviors in friendly and threat forces.** The development of Combat Instruction Sets (CIS) in CCTT SAF continues. A CIS is defined as a computer generated representation of tactical combat behavior at the unit and platform level. The structure of CISs must include all elements needed for software engineers to translate the combat representation into instructions understandable by a computer. Currently, over 200 CISs have been developed for the CCTT SAF program. These CISs provide traceability for CCTT SAF behavioral representations as they have been extensively validated. Where possible, the CISs should be used as a basis for behavioral implementation in ModSAF or other SAFs.

**Support to the development of the High Level Architecture (HLA).** The Architecture Management Group (AMG) has been established by the Under Secretary of Defense for Acquisition and Technology to oversee development of the high-level architecture (HLA) for simulation. This group began operation in March 1995. It will use the initial description of the HLA synthesized from the results of the ARPA Advanced Distributed Simulation architecture projects and other relevant projects sponsored by DOD. This year, the AMG will review and evaluate a series of prototypes conducted to test and further define the architecture. Based on the results of these prototypes and other analyses, the AMG will prepare a baseline definition of the HLA to be available in the fourth quarter of FY 96. This architecture will be recommended to the Executive Council for Modeling and Simulation (EXCIMS), who, after appropriate review, will submit it to the Under Secretary of Defense (Acquisition and Technology) for approval. During the course of its work, the AMG will review its activities with the Modeling and Simulation Working Group (MSWG) that supports the EXCIMS.

**Integration of simulators with constructive models.** Research into interfacing constructive and virtual systems has continued. At TRAC-WSMR, the constructive model CASTFOREM has been made DIS compliant, providing the analyst a window into the virtual world. The WARSIM program, a constructive simulation, will include the ability to link to live and virtual simulations, as well as other DIS compatible simulations. The need to populate the BDS-D environment with an accepted SAF prompted a project to enhance Janus for interaction in a DIS environment. The project has successfully brought the validated and accredited scenarios developed over the years to the DIS world; and the incorporation of Janus into the DIS environment provides an OPFOR or adjacent unit simulation without requiring extensive computer resources. DIS provides a man-in-the-loop simulation and reactive capability previously unavailable to Janus.

**Emergence of the OneSAF concept.** There are architectural and modeling challenges to the development of a OneSAF model. High risk areas that need further research include the requirements for composability, interoperability with other models, scalability, behavioral automation at the battalion level, and the need to operate in both closed form and with human-in-the-loop.

## SAF IMPROVEMENTS IN FY 97 AND THEIR SUPPORT TO STANDARDS OBJECTIVES.

| SAF Improvement | Standardization Objective Supported |
|---|---|
| V&V of portions of ModSAF | 1,4 |
| STOW baseline improvements | 5 |
| OneSAF MNS is approved; ICT formed | 1,2,3,4,5 |
| Formal ModSAF CM improves | 1,4 |

Figure 1. SAF Improvements and Standardization Objectives

Verification and validation of portions of ModSAF. Validation efforts are continuing for ModSAF with mixed results. The release of version 3.0 was postponed for three months while key fixes were made that were uncovered during validation testing. STRICOM has developed a web-based V&V program that will allow beta test sites to input results of tests that might have previously been lost due to a lack of consistent recordkeeping.

*Semi-Automated Forces*

STOW baseline SAF improvements. The STOW program continues to enhance and generally improve the functionality of the ModSAF baseline. Additions that have not yet been formally accepted by the Army include the Global Coordinate System, HLA compliance, RWA enhancements, CFOR fixes, and JCOS functionality.

OneSAF Mission Needs Statement (MNS) is approved and a ICT is formed. The OneSAF MNS was approved in May, 1997 by the TRADOC Commander and an ICT was formed to address the program's multi-domain requirements, management structure, acquisition strategy, and technical risk. The CGF Assessment identified the need for a new software architecture that would provide an object oriented environment for a truly composable SAF. The results of the ICT are scheduled to be briefed to the AMSEC in September, 1997.

Formal configuration control process for ModSAF improves. Based on the CGF assessment, the PM DIS was given the lead for developing a coordinated (AMSAA, NSC, TRAC) configuration process and implementation plan for managing ModSAF requirements, development, and V&V. STRICOM has implemented an on-line configuration status accounting (CSA) system for managing the process. The ModSAF CM Plan and ModSAF Program Plan have been approved by all voting members. Both describe the ACR, TEMO, and RDA domain responsibilities in managing the model development. Though still evolving, the program has improved tremendously in the past year.

**FOCUS FOR FY 97 AND UPDATED ROADMAP (Figure 4).**

| Focus Areas | Standardization objectives |
|---|---|
| SAF Editor Capability | 1,2,5,6 |
| Consistent physical model representations | 1,2,6 |
| Standard behavioral implementations | 1,2,4,5,6 |

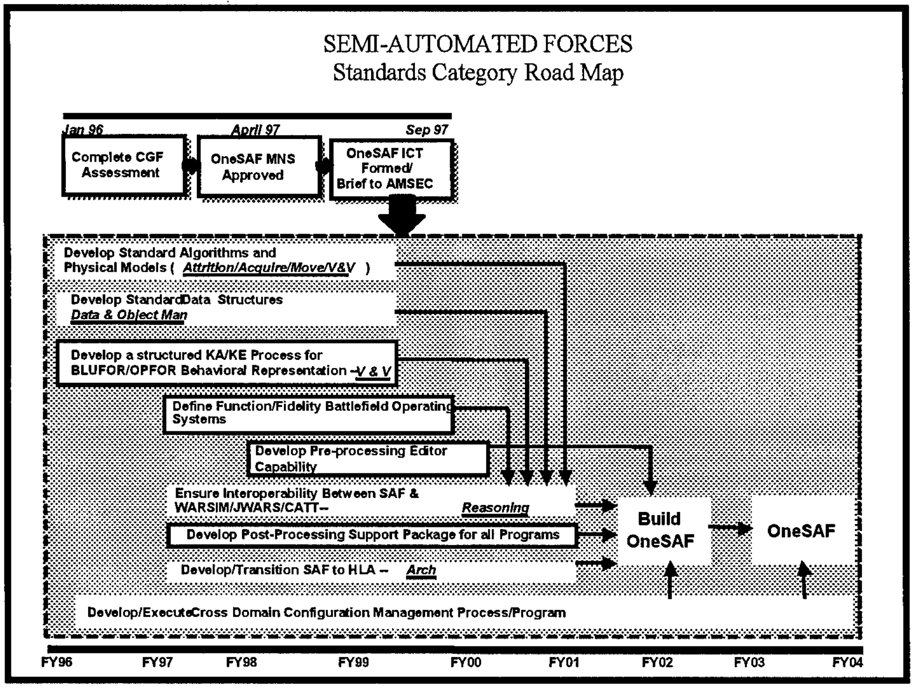
Figure 2. Focus Areas and Standardization Objectives

SAF Editor Capability. In order to serve as an analytical or research tool, SAFs must have the capability to allow the operator to edit entities through the use of a graphical user interface. Currently, editing capability exists only through the alteration of data files that are cumbersome to edit for the average operator. This limitation is a major hindrance to using the current SAFs as analytical tools.

Consistent physical model representation. SAFs vary in the quality and fidelity of the physical models used within their architectures. Object-oriented techniques should be used in the development of OneSAF, and these physical models should be validated by the appropriate source.

Consistent representations within ModSAF and CCTT SAF to enhance reuse and interoperability. Consistent representations within SAFs will provide a basis for reuse and interoperability. During FY 96 TRAC implemented 20 BLUFOR CCTT SAF CISs in ModSAF. The demonstration proved that this implementation would improve the quality of the behaviors in ModSAF, and this work should be continued and expanded to address the key OPFOR CISs that serve as a basis for a majority of the enemy behaviors in ModSAF.

## SAF ROADMAP


SEMI-AUTOMATED FORCES
Standards Category Road Map
Jan 96
April 97
Sep 97
Complete CGF Assessment
OneSAF MNS Approved
OneSAF ICT Formed/ Brief to AMSEC
Develop Standard Algorithms and Physical Models ( Attrition/Acquire/Move/V&V )
Develop StandardData Structures Data & Object Man
Develop a structured KA/KE Process for BLUFOR/OPFOR Behavioral Representation -V & V
Define Function/Fidelity Battlefield Operating Systems
Develop Pre-processing Editor Capability
Ensure Interoperability Between SAF & WARSIM/JWARS/CATT-- Reasoning
Develop Post-Processing Support Package for all Programs
Develop/Transition SAF to HLA -- Arch
Build OneSAF
OneSAF
Develop/ExecuteCross Domain Configuration Management Process/Program
FY96
FY97
FY98
FY99
FY00
FY01
FY02
FY03
FY04

# Annual Standards Category Report for FY98

# TERRAIN

## INTRODUCTION

The U.S. Army Topographic Engineering Center (TEC) serves as the Army's lead coordinating agency for the advancement of standards for Army Modeling and Simulation (M&S) in the area of terrain in partnership with the Department of Defense (DoD) M&S Executive Agent (EA) for Terrain, the National Imagery and Mapping Agency (NIMA) Terrain Modeling Project Office (TMPO). Within TEC, the Digital Concepts and Analysis Center (DCAC) serves as the Army's Standards Category Coordinator (SCC) for Terrain and is responsible for administering the standards development process for this category outlined in the Army Model and Simulation Master Plan, 18 May 1995. Category coordinator responsibilities include: (1) managing the technical standardization process for standards development and evolution, (2) submitting an annual report on the status of standardization with each category, and (3) nominating annual projects for Army Model Improvement Program (AMIP) investment consideration.

Collectively, the standards categories for Terrain and Dynamic Environment, chaired by the U.S. Army Research Laboratory (ARL), support the Army and DoD M&S objectives of providing timely and authoritative environmental representations.

## STANDARDS CATEGORY DEFINITION

The Terrain category includes the objects, algorithms, data, and techniques required to represent terrain and dynamic terrain processes in modeling and simulation.

## TERRAIN (STATIC AND DYNAMIC) DEFINITION

Dynamic terrain allows for terrain changes to be introduced during a simulation. Examples include earth moving and cratering due to weapon effects. In contrast, static terrain does not change after a simulation has been started.

## STANDARDS DEVELOPMENT PROCESS

The Army's standards development process is continuous and iterative in nature. The Terrain category road map depicts this process as a on-going series of activities beginning with the establishment of teaming relationships that will support in (1) defining the standards and services required, (2) developing the technical and procedural standards identified, (3) staffing the draft standards developed to achieve community consensus, (4) promoting Army and DoD repositories, and (5) educating and assisting Army users on said activities.

Army organizations supporting the Terrain standards development process in cooperation with TEC include: U.S. Army TRADOC Analysis Center (TRAC), TRAC White Sands Missile Range (WSMR), U.S. Army Simulation, Training and Instrumentation Command (STRICOM), Concepts Analysis Agency (CAA), U.S. Army Engineer School (USAES) and TRADOC Program Integration Office for Terrain Data (TPIO-TD), National Simulation Center (NSC), NIMA TMPO, U.S. Army Materiel Systems Analysis Activity (AMSAA), U.S. Army Operational Test and Evaluation Command (OPTEC), U.S. Army Waterways Experiment Station (WES), Deputy Chief of Staff for Intelligence (DCSINT), and HQ TRADOC Deputy Chief of Staff for Simulations and Analysis (DCSSA).

## STANDARDS REQUIREMENTS

The standardization objectives of the Terrain category include:

1. Defining digital terrain data content, resolution and accuracy requirements for developmental models and simulations.
2. Developing correlated terrain databases.
3. Developing techniques for rapid terrain database generation.
4. Developing techniques for dynamic terrain features.
5. Developing a consensus based data exchange standard.
6. Developing reuse repositories.

## ACCOMPLISHMENTS AND ASSESSMENT

A number of Army and DoD investment programs exist to support the standards development process and the development and transfer of emerging M&S technologies. These programs include the Army Model Improvement Program (AMIP) and Simulation Technology (SIMTECH) program. The Defense Modeling and Simulation Office (DMSO) through the M&S EAs for Terrain, Oceans, and Atmosphere also funds studies and projects that support DoD M&S objectives. Due to limited funds, only a small number of projects are funded each year from these investment programs. In FY96 and FY97, no Terrain category projects were funded by the AMIP program. Despite the lack of AMIP funding for Terrain category projects in recent years, TEC, NIMA, the Defense Advanced Research Projects Agency (DARPA) and others continue to dedicate declining resources to vital research and development efforts that are attempting to address stated Army and DoD M&S terrain and functional capability requirements. Specific requirements identified by the Army include: (1) Realistic 3D terrain representations, (2) Correlated terrain databases, (3) Standard terrain databases, (4) Dynamic terrain features, (5) Techniques for rapid terrain generation, and (6) Realistic soil and feature properties.

### Accomplishments

During FY97, the following terrain related studies and projects were initiated:

1. ***Geospatial Data for the 21st Century Land Warrior Videotape.*** To sensitize Army planners and users to the level of effort, time, and resources required to satisfy Army high resolution terrain data requirements in an era of declining resources, rapid change, and a global land combat mission, DCAC is producing an educational videotape in FY97 entitled "Geospatial Information for the 21st Century Land Warrior." This videotape will also educate the Army Warfighter and user community to the changes currently underway within the Geospatial Information and Services community; to the information and services that can be expected in the future; to the processes for stating terrain requirements; and to the challenges that remain for satisfying very high resolution terrain requirements to support all applications as the Army moves into the next century.

2. ***Standard Algorithms for Environment/Terrain Project.*** This Verification, Validation, and Accreditation (VV&A) AMIP project was funded in FY97 to catalog environment and terrain algorithms for reuse within the M&S community. The catalog will contain information on algorithms which reasonably model or simulate dynamic environment and terrain processes.

3. ***Extreme Geospatial Information Packing for Terrain (EGIPT).*** The objective of this FY97 funded SIMTECH project is to produce a prototype database using continuous mathematical functions to represent terrain information, both elevations and features. Based on the Variable Resolution Terrain (VRT) work performed by ARL, the goal of this

project is to extend the VRT method of expressing elevations as mathematical functions to features. Regrettably, not all of the goals of this project will be realized due to the early retirement of the principal investigator performing this work.

4. ***Line-of-Sight (LOS) Reuse Study.*** The goal of this TEC study is to develop a frame work (i.e., documentation standards, software tools, data sets, procedures) that can be used to verify and validate several LOS methods being used by the Army and to install this software into the Army Reuse Center (ARC) Mapping, Charting and Geodesy (MC&G) software reuse library.
5. ***DCAC Home Page (http://www.tec.army.mil/PD/dcac/dcac.htm).*** The DCAC home page was updated in FY97 to include a "DCAC Support to M&S" section. This site will be used to communicate SCC for Terrain activities.

**Related Activities Assessment**

In addition to the studies and projects previously mentioned, the following related activities reflect vital research and development efforts that are attempting to address stated Army and DoD M&S terrain and functional capability requirements.

1. ***Synthetic Theater of War (STOW) 97.*** STOW97 is an Advanced Concept Technology Demonstration (ACTD) jointly sponsored by DARPA and the United States Atlantic Command (USACOM). TEC's Topographic Applications Laboratory is executing the SE STOW program, under the direction of DARPA's SE Program manager. The STOW program seeks to demonstrate technologies enabling the integration of warfighting with: (1) live instrumented simulation ranges; (2) manned virtual simulators; and (3) constructive simulations from geographically distributed locations into a common synthetic battlespace. STOW97 program components include:

   a. ***Dynamic Virtual Worlds (DVW).*** DVW will integrate environmental feature models within the Modular Semi-Automated Forces (ModSAF), and complementary real-time visualization systems, currently Loral's Vistaworks and Silicon Graphics' Performer. Key feature models being integrated include battlefield smoke, atmospheric transmittance, time of day, shadowing, signal and illumination flares, vehicle dust, clouds, thunderstorms, precipitation, dust clouds, explosions and weapon effects, trafficability and mobility, and hydrologic modeling.

   b. ***Dynamic Terrain and Objects (DTO).*** DTO will develop dynamic terrain and object capabilities in ModSAF, and complementary real-time visualization systems, currently Loral's Vistaworks and Silicon Graphics' Performer. Two basic levels of dynamic terrain and objects will be supported. Level 1 supports changes in terrain databases or object geometry during simulation run-time. Requirements for Level 1 dynamic terrain are focused on combat engineering requirements to include cratering, minefield breaching, anti-tank ditch breaching, and breaching of other combat emplaced obstacles. Level 2 dynamic terrain supports multi-state objects which have potential for instantiating a variety of health or damage states (i.e., healthy bridge, damaged bridge, destroyed bridge). The first generation of dynamic terrain will include scatterable and standard emplaced mines and minefields, road craters, anti-tank ditches, obstacles, survivability positions, bridge demolitions, highway overpass demolitions, and railroad demolitions.

   c. ***Integrated Computer Generated Forces Terrain Database (ICTDB).*** ICTDB will represent a new capability in terrain database representation. This new representation will accommodate multiple data sources with integrated feature and elevation data. There will be extended terrain feature attributes including attributes for weather effects.

Multiple elevation surfaces, such as the ocean surface over the ocean floor, caves, tunnels, and buildings will be implemented. Aggregated features will support maneuver by higher echelons. The ICTDB will support a global coordinate reference system. The ICTDB is also designed to facilitate real-time terrain updates. This new terrain database representation will support significantly more environmental effects than are now available to Computer Generated Forces (CGF) systems, and will allow for improved interoperability among virtual and constructive simulations.

d. ***STOW Terrain Databases (TDBs).*** The STOW program is developing a suite of advanced TDBs that satisfy high, medium, and low fidelity requirements. Current and projected STOW TDBs being produced by TEC's DPC include:

- ⇒ Twenty-nine Palms Range 400 - High fidelity/Dismounted Infantry level TDB
- ⇒ Camp Pendleton, CA - Medium fidelity/Mechanized level TDB
- ⇒ SW USA- Low fidelity/Theater level TDB
- ⇒ SW USA Ground Maneuver Box - Medium fidelity/Mechanized level TDB
- ⇒ SW Asia - Low to High fidelity/Theater to Dismounted Infantry level TDB

2. ***Military Operations in Built-up Areas (MOBA) TDB and Evaluation Project.*** The MOBA TDB is a high fidelity TDB of the Ft. Benning McKenna Military Operations in Urban Terrain (MOUT) site. TEC produced this database for the Dismounted Battlespace Battle Lab (DBBL) to support dismounted infantry simulations and Warfighter evaluations. The final TDB is formatted for ModSAF, Loral's Vistaworks, and Silicon Graphics' Performer applications. The information obtained from the evaluation of these TDBs and associated data products will be instrumental in assessing whether these Build 1, very high resolution M&S TDBs satisfactorily meet the Warfighter's dismounted infantry level simulation requirements for urban terrain.

3. ***Rapid Construction of Virtual Worlds (RCVW).*** The RCVW program, funded by DMSO, is focused on continued research in computer assisted and automated processes in the building of M&S TDBs through transformation of standard NIMA digital topographic data (DTD) elevation, feature, and controlled imagery products. The goals of the RCVW effort include rapid terrain data (elevation and feature) generation from imagery products; very high resolution modeling of terrain, structures, and vegetation; and TDB verification.

4. ***Synthetic Environments Data Representation and Interchange Specification (SEDRIS).*** The goal of SEDRIS is to provide a means for exchanging terrain data among heterogeneous models, simulations, and simulators rapidly, effectively, and with minimum data loss. In the absence of a robust interchange mechanism, STRICOM, DARPA, and DMSO have initiated this effort to develop a consensus based standard interchange mechanism.

5. ***Rapid Terrain Visualization Advanced Concept Technology Demonstration (RTV ACTD).*** The objective of the RTV ACTD is to demonstrate capabilities to rapidly collect source data, generate high resolution digital terrain elevation data and feature data, and transform these data sets into databases for legacy and objective systems that support terrain evaluation, analysis and visualization. At the direction of the Deputy Assistant Secretary of the Army for Research and Technology (DASA-R&T), the Joint Precision Strike Demonstration Project Office (JPSD-PO) was asked to develop a concept for the RTV ACTD in June 1995. The concept developed was subsequently approved as a 4 year program beginning in FY97.

## PRIORITIES FOR NEXT YEAR

Five Terrain category proposals were submitted in response to the FY98 call for AMIP proposals dated 3 April 1997. The titles of the projects and submitting organizations include:

1. *The Effect of Feature Data on Line-of-Sight (LOS)*, TEC and TRAC WSMR.
2. *Automatic Feature-Based Database Construction Tools*, TEC.
3. *WARSIM Terrain Requirements Determination Study*, TEC.
4. *River Simulation (RIVSIM) Optimization and VV&A*, U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) and WES.
5. *Raster Data in Distributed Simulation*, TEC.

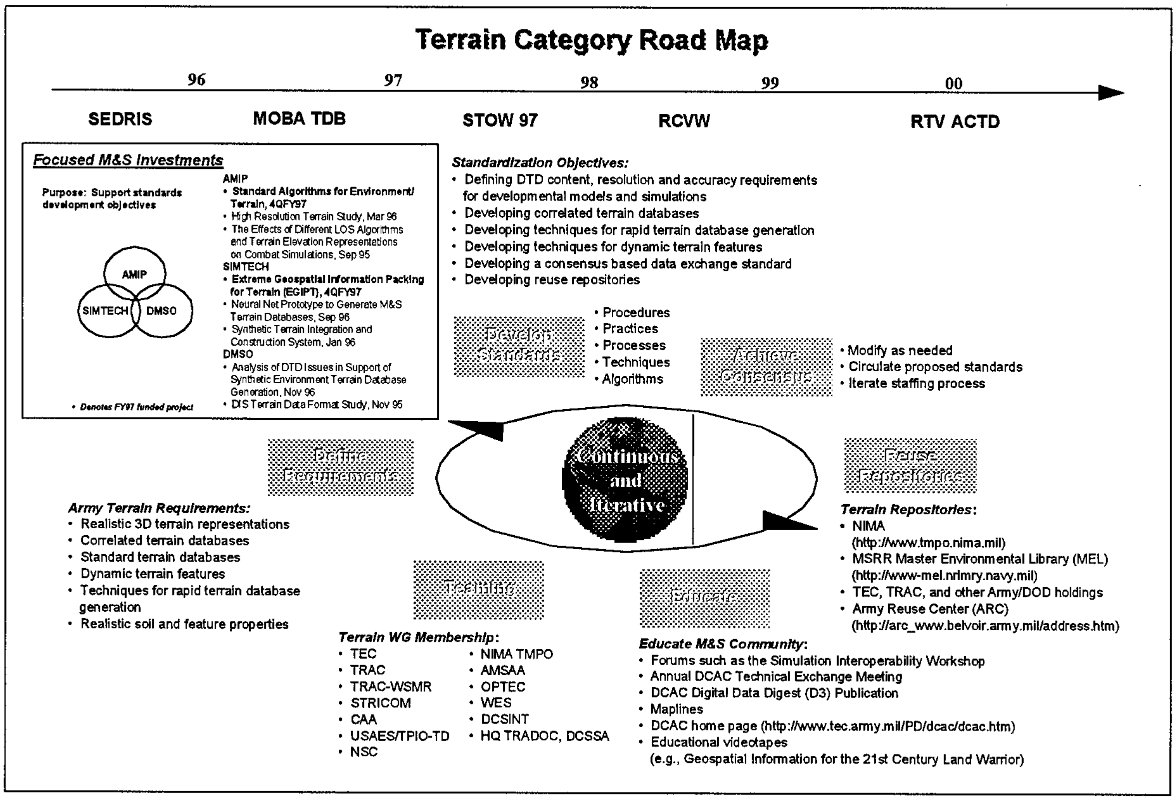
Each of the projects submitted was evaluated and rank ordered by the Terrain Working Group participants attending the AMSO sponsored Army M&S Standards Workshop held at Carlisle Barracks from 5-8 May 1997. The top three proposals are nominated for Army Model and Simulation Management Program Working Group (AMSMP WG) FY98 funding consideration.

The number one proposal, *The Effect of Feature Data on Line-of-Sight (LOS)*, builds on the body of work performed in recent years to better understand the technical issues associated with LOS prediction for Army applications. Prediction of realistic LOS conditions has always been an essential aspect of combat simulations. However, most of the work to date has examined a "bald-earth" scenario using elevation data to represent the earth's surface. Consequently, the representation of LOS in areas with surface features (e.g., vegetation) has not been extensively examined to understand how vegetation impacts LOS predictions. TEC and TRAC-WSMR recognize this problem and have developed a study to: (1) identify geotypical feature density zones; (2) document typical LOS within each with a field collection effort; and (3) predict future LOS performance.

The number two proposal, *Automatic Feature-Based Database Construction Tools*, will develop software tools to automatically construct simulation databases by linking NIMA DTD products to TEC's library of 3D Computer Aided Design (CAD) models of terrain features and textures.

The number three proposal, *WARSIM Terrain Requirements Determination Study*, will support the timely identification and definition of WARSIM terrain data requirements in cooperation with the NSC, STRICOM, TPIO-TD, DCSINT, and NIMA. The timely articulation of WARSIM terrain data requirements is essential for program success.

## ROAD MAP



Terrain Category Road Map
96
97
98
99
00
SEDRIS
MOBA TDB
STOW 97
RCVW
RTV ACTD
Focused M&S Investments
Purpose: Support standards development objectives
AMIP
SIMTECH
DMSO
AMIP
• Standard Algorithms for Environment/ Terrain, 4QFY97
• High Resolution Terrain Study, Mar 96
• The Effects of Different LOS Algorithms and Terrain Elevation Representations on Combat Simulations, Sep 95
SIMTECH
• Extreme Geospatial Information Packing for Terrain (EGIPT), 4QFY97
• Neural Net Prototype to Generate M&S Terrain Databases, Sep 96
• Synthetic Terrain Integration and Construction System, Jan 96
DMSO
• Analysis of DTD Issues in Support of Synthetic Environment Terrain Database Generation, Nov 96
• DIS Terrain Data Format Study, Nov 95
• Denotes FY97 funded project
Standardization Objectives:
• Defining DTD content, resolution and accuracy requirements for developmental models and simulations
• Developing correlated terrain databases
• Developing techniques for rapid terrain database generation
• Developing techniques for dynamic terrain features
• Developing a consensus based data exchange standard
• Developing reuse repositories
Develop Standards
• Procedures
• Practices
• Processes
• Techniques
• Algorithms
Achieve Consensus
• Modify as needed
• Circulate proposed standards
• Iterate staffing process
Define Requirements
Continuous and Iterative
Reuse Repositories
Army Terrain Requirements:
• Realistic 3D terrain representations
• Correlated terrain databases
• Standard terrain databases
• Dynamic terrain features
• Techniques for rapid terrain database generation
• Realistic soil and feature properties
Terrain Repositories:
• NIMA (http://www.tmpo.nima.mil)
• MSRR Master Environmental Library (MEL) (http://www-mel.nrlmry.navy.mil)
• TEC, TRAC, and other Army/DOD holdings
• Army Reuse Center (ARC) (http://arc_www.belvoir.army.mil/address.htm)
Educate
Terrain WG Membership:
• TEC
• TRAC
• TRAC-WSMR
• STRICOM
• CAA
• USAES/TPIO-TD
• NSC
• NIMA TMPO
• AMSAA
• OPTEC
• WES
• DCSINT
• HQ TRADOC, DCSSA
Educate M&S Community:
• Forums such as the Simulation Interoperability Workshop
• Annual DCAC Technical Exchange Meeting
• DCAC Digital Data Digest (D3) Publication
• Maplines
• DCAC home page (http://www.tec.army.mil/PD/dcac/dcac.htm)
• Educational videotapes (e.g., Geospatial Information for the 21st Century Land Warrior)

## Annual Standards Category Report for FY98

## VERIFICATION, VALIDATION, AND ACCREDITATION

### STANDARD CATEGORY DEFINITION

Verification is the process of determining if the M&S accurately represents the developer's conceptual description and specifications and meets the needs stated in the requirements document. The verification process evaluates the extent to which the M&S has been developed using sound and established software engineering techniques, and establishes whether the M&S logic and code correctly perform the intended functions.

Validation is the process of determining the extent to which the M&S adequately represents the real-world from the perspective of its intended use. This process ranges from single modules to the entire system. Validation methods will incorporate documentation of procedures and results of all validation efforts to assist accreditation.

Accreditation is an official determination that the M&S is acceptable for its intended purpose. Accreditation is a management responsibility of the application sponsor, assisted by the V&V agent.

### STANDARDS REQUIREMENTS

1. Establish and define standard verification, validation, and accreditation processes.
2. Build verification and validation tools and guidelines.
3. Make the above tools available to users.
4. Develop measures of effectiveness to identify key elements and establish validation tolerances.

### ACCOMPLISHMENTS AND ASSESSMENTS

Fiscal year 1997 saw several VV&A projects completed to include the Army Model Improvement Program funded project to create a tool for model fidelity characterization. A copy was made available to the Fidelity Taxonomy subgroup of the DIS workshop for their work in fidelity characterization.

Also completed and delivered to AMSO was the VV&A tutorial on CD-ROM disk. A copy of the disk will be made available to interested modelers through out the M&S community. We are also exploring the possibility of placing the tutorial on the world wide web for downloading or interactive use.

The DMSO Tech Team completed and published the DMSO sponsored *Recommended Practices Guide to VV&A.* The guide can be downloaded from DMSO's document library at www.dmso.mil along with other M&S related documents such as DoD Instruction 5000.61, *DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A)*, April 29, 1996.

We are pleased to announce the *Recommended Practices for Verification, Validation, and Accreditation of Distributed Simulations* was accepted on first ballot for IEEE Standard 1278.4. This document is the cumulation of an exceptional effort by several agencies from the services, industry, and academia under sponsorship of DMSO. The document is currently in final draft in which comments from the balloting committee will be incorporated and made ready for publishing.

Finally, but very significant, we initiated another volume for the Algorithm Standards Library.

The project is being funded by the FY97 Army Model Improvement Program. This effort will involve the collection and documentation the best available algorithms for modeling environment and terrain as determined by a working group of subject matter experts. The TRADOC Analysis Center is the lead agency with assistance from the Topographic Engineer Center and the Army Research Laboratory.

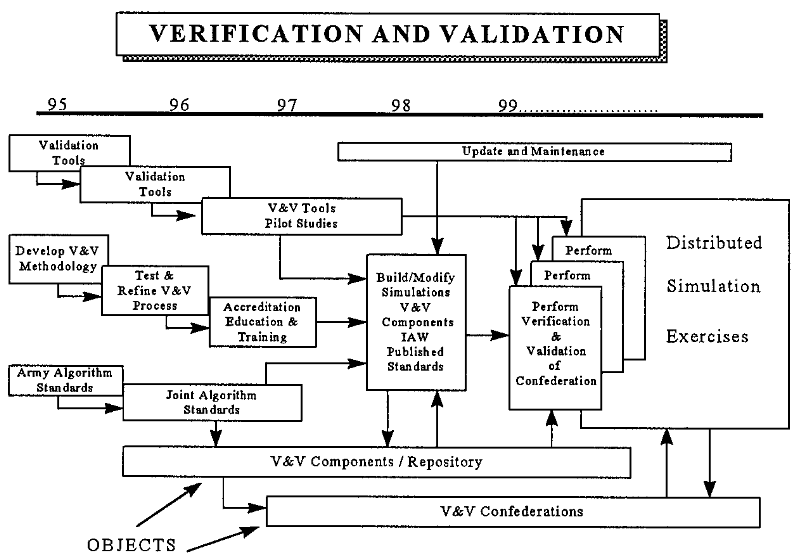
We are also creating electronic versions of all entries into the Library. The plan is to make the Library available for download from a world wide web site and on CD-ROM disk. The "final resting place" for the web version of the Library is yet to be determined – perhaps the Model & Simulation Resource Repository (MSRR). For the present, some volumes can be found on TRAC's web site, www.trac.army.mil/vva. This section is password protected but the password may be obtained by contacting the VV&A SCC via e-mail at cantwell@trac.army.mil or solicks@trac.army.mil.

## PRIORITIES FOR FISCAL YEAR 1998

The completion of the Algorithm Standards Library remains a high priority for the VV&A Standards Category. Standard algorithms along with standards in communication and data will contribute significantly to VV&A as well as simplifying the process. Funding continues to be a problem with this effort, however, we are making progress, slowly but surely.

We should continue to develop tools which will assist the M&S proponents and/or their V&V agents especially in the area of storing and retrieving VV&A data about models and simulations. The VV&A community should also look at the High Level Architecture; expanding the work previously completed in distributed simulations into that arena.

## ROADMAP



## Annual Standards Category Report for FY98

## VISUALIZATION

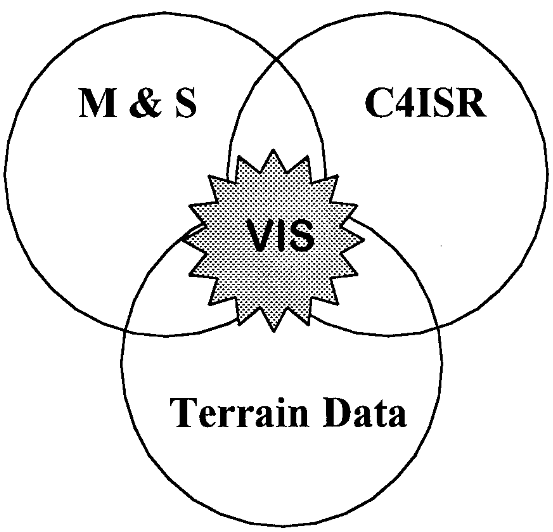
### STANDARDS CATEGORY DEFINITION

The process that develops hardware, software and procedural standards to provide a seamless vision of the battlespace by incorporating and integrating the environment, entities and their psychologies across virtual, constructive and live simulations. This enables leaders, decision-makers, staffs and soldiers at all levels to attain cognitive awareness of the battlespace.

### STANDARDS REQUIREMENTS

Visualization embraces graphical user interfaces (GUIs), icon attributes, the military decision making process, cognitive processes, databases, and fielding plans. Models and simulations contain intrinsic GUIs, enable analysis to develop visualization tools, and stimulate C4ISR for battlefield visualization. Establishing standards ensures software and hardware are interoperable and synchronized across domains using germane technology. Standards make potentially diverse and complex requirements manageable for the researcher by providing focus. Standards inform the developer of guidelines he must meet beforehand thus preventing redesign. Lastly, analysts, trainers and warfighters benefit from habitual association to things they see, hear, feel, and smell when using synthetic environments. Visualization requirements summarized:

1. Determine how Visualization relates to the other standards categories and to C4ISR.
2. Define and articulate attainable, adaptable, and scaleable standards.
3. Implement standards.




Visualization is closely associated with battlefield visualization and command, control, communications, computers, intelligence, surveillance (C4ISR). Both models and simulations, and C4ISR ultimately must portray situational information for decision-makers. These two parallel worlds relate closely to a third, which is environment. M&S and C4ISR are both customers of environmental data, particularly terrain data. Visualization relates with the other categories as well either directly in the portrayal of information or indirectly in the origin of information.

### ACCOMPLISHMENTS AND ASSESSMENT

Visualization officially became a Standards Category on 22 April 1997. Immediately following, the visualization team convened for the SCC workshop at Carlisle Barracks 4 through 8 May.

The team explored visualization applicability, found that the category is expansive, and concluded on an inaugural focus.

| | Synthetic Environment | | |
|---|---|---|---|
| Domain | Live | Virtual | Constructive |
| TEMO | | | ★ |
| ACR | | ★ | |
| RDA | | | ★ |

The focus is characterized by the type of synthetic environment for each M&S domain.

The intent of the focus is to prioritize efforts, but is not intended to omit initiatives in other domain environments.

## PRIORITIES FOR FUTURE WORK

The first priority is to form a strong, interdisciplinary team from research, development, and user organizations. Then this team will assess operational, systems, and technical continuity between M&S domains and warfighter requirements. To do this, the team will survey the M&S, C4ISR, industry, academia, and research communities. Visualization as a new category has wide application for providing by sensory stimulation to produce cognitive awareness of the battlefield. Leveraging ongoing visualization efforts and identifying deficiencies must precede formal establishment of visualization standards.

## AMIP ARCHITECTURE ALIGNMENT SUMMARY

Technical Approach.

1. Identify operational, systems, and technical visualization standards requirements for Training, Exercise, and Military Operations (TEMO), Research, Development, and Acquisition (RDA), and Advanced Concepts and Research (ACR) domains.
2. Identify current use of visualization or visualization related standards.
3. Identify and define visualization products in the Army, Department of Defense (DoD), academia, research institutes, and industry. Categorize products in use or under

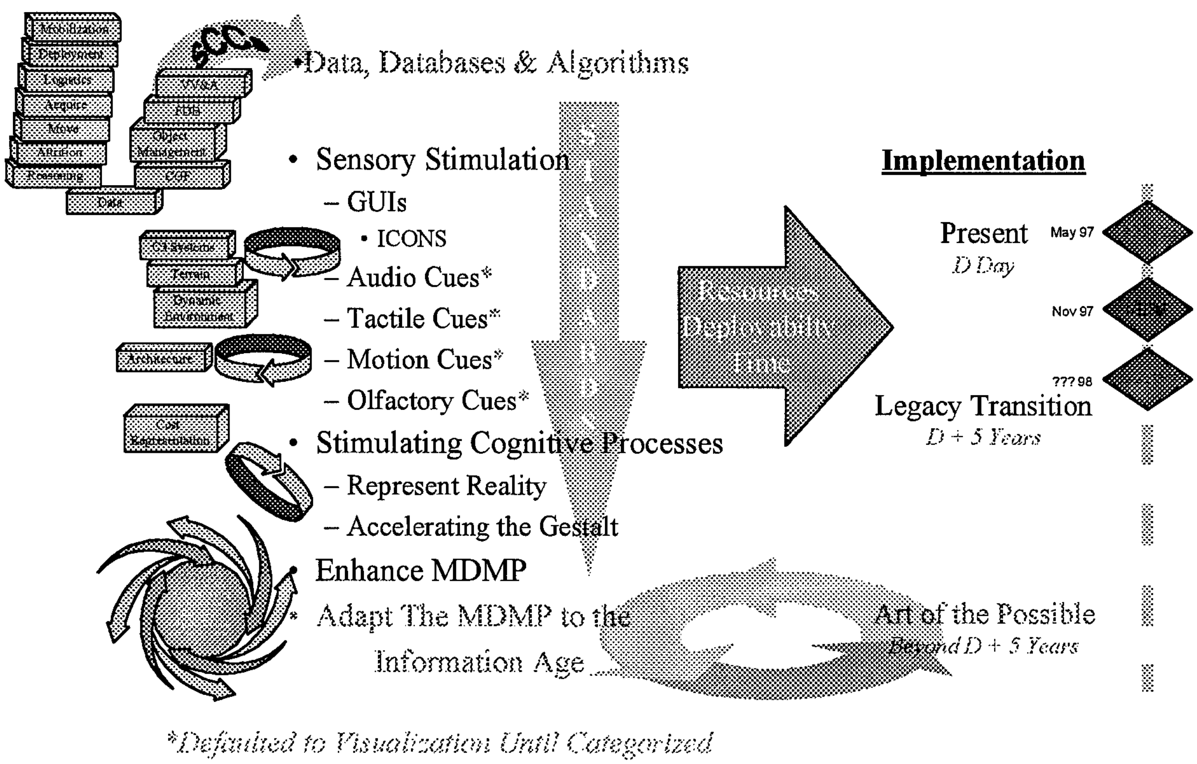
development by the three levels of architecture, deployment and retirement timelines, and domain usage.

4. Assess utility of existing standards. Update inadequate standards and create standards where deficiencies exist.

Products.

1. Visualization Template to establish requirements using off the shelf office software.
2. Developmental Matrix for visualization standards implementation using off the shelf office database software.

**ROADMAP**



## APPENDIX D

### AMIP Proposals Approved to Receive FY98 Funding (sorted by Project Name)

## APPENDIX D

### AMIP Proposals Approved to Receive FY98 Funding (sorted by Standards Category)

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*AMIP-98-MOVE-02*

**PROJECT TITLE** **Air Battle Algorithms - Air Platform Movement**

**STANDARDS CATEGORY** Move

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## EXECUTIVE SUMMARY

This study will assess the adequacy of algorithms in replicating the required platform movement capabilities of aircraft systems, to include rotary wing aircraft, in selected models under development. The study will identify perceived deficiencies in the replication of the capabilities of aviation systems in existing models and simulations, determine whether required algorithms are available for use by model developers, and identify requirements for the development of new algorithms. In conducting this study, researchers will leverage previous investigations of algorithms by Standards Category Move.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. While significant enhancements to the CBS have substantially improved the replication of aircraft systems, CBS does not replicate rotary wing air combat, identified as a requirement in WARSIM ORD v.3.0. Other deficiencies have been identified in the replication of aviation systems in STOW and ModSAF. The capabilities of aircraft systems have been replicated in non-FAMSIM models and simulations; however, it is unclear whether such algorithms, if proprietary, will be available to developers of WARSIM, JSIMS, JWARS, CATT Core, OneSAF, etc.

2. In 1994 the *Army Times* carried a headline proclaiming that the Comanche had not performed well in simulation. What it did not report was that an icon had been labeled a Comanche without replicating its capabilities, a situation which denied readers accurate feedback on the goodness of a key system in winning the Information War.

3. Some simulations, such as ATCOM and ITEMS, model desired aircraft characteristics, but these are proprietary models and it is not clear whether the goodness of these models may migrate into emerging simulations, such as WARSIM 2000.

## TECHNICAL APPROACH

The technical approach can be divided into 7 general tasks.

1. Define measures of performance (MOPs) based on key characteristics of Army Aircraft to be modeled. MOPs will be based on input from the Aviation Center, TSM-Comanche, TSM-Longbow, and PEO Aviation. Measures of effectiveness (MOEs) will be derived from MOPs.

2. Identify the requirements for replicating the characteristics of aircraft systems, with emphasis on the Longbow, Comanche, and Kiowa Warrior, as objects (entities) in selected simulations under development.

3. Research current methodologies for aircraft movement and identify the best algorithms for replicating aircraft systems.

4. Identify deficiencies of current aircraft movement algorithms.

5. Based on results from steps 1 through 4, identify optimum set of algorithms for potential standardization of Army models.

6. Propose areas for additional methodology development where needs exist

7. Establish milestones for development of new algorithms for air movement in coordination with model developers.

## PRODUCTS

AMSAA will assess algorithms for both rotary and fixed wing aircraft. Findings will be documented in a technical report. Final report will include recommendations regarding air platform movement algorithm standards to include those for rotary wing aircraft and computer generated forces (semi-automated forces).

## MILESTONES

FY 98

- Feb 98: Complete development of necessary expertise pertaining to applicable Army models.

- Mar 98: Define MOPs/MOEs and identify aircraft platform performance requirements as pertain to identified models.

- Apr 98: Complete literature search of existing aircraft performance algorithms from identified models and compare to requirements. Determine if and where deficiencies exist.

- May 98: Develop set of optimal aircraft movement algorithms and establish a plan for development of new algorithms for standardization to address identified deficiencies.

- June 98: Document results in report.

## RISK/BENEFIT ANALYSIS

The technical risk is moderate to low. The results of the study will provide to WARSIM, JSIMS, and JWARS developers, et al, a reference for the representation of aircraft mobility and could provide the basis for a standard for air movement in constructive and virtual simulations.

## EXECUTABILITY

This study will be executed by AMSAA and will have the full support of the Aviation Center for the identification of perceived deficiencies and perceived advantages in current models and simulations. Such support will be drawn from subject matter experts within the aviation community.

*AMIP-98-VIS-01*

**PROJECT TITLE** **Architecture Alignment**

**STANDARDS CATEGORY** Visualization

**POINT OF CONTACT**

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## EXECUTIVE SUMMARY

Architecture alignment provides operational, systems, and technical continuity between M&S domains and warfighter requirements. The intent of this project is to survey the M&S, C4ISR, industry, academia, and research communities in order to synchronize visualization efforts, define areas of focus and category boundaries, and establish a robust team. Visualization as a new category has wide application for providing by sensory stimulation to produce cognitive awareness of the battlefield. Leveraging ongoing visualization efforts and identifying deficiencies must precede formal establishment of visualization standards.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

Visualization embraces graphical user interfaces (GUIs), icon attributes, the military decision making process, cognitive processes, databases, and fielding plans. Models and simulations contain intrinsic GUIs, enable analysis to develop visualization tools, and stimulate C4ISR for battlefield visualization. Establishing standards ensures software and hardware are interoperable and synchronized across domains using germane technology. Standards make potentially diverse and complex requirements manageable for the researcher by providing focus. Standards inform the developer of guidelines he must meet beforehand thus preventing redesign. Lastly, analysts, trainers and warfighters benefit from habitual association to things they see, hear, feel, and smell when using synthetic environments.

## TECHNICAL APPROACH

1. Identify operational, systems, and technical visualization standards requirements for Training, Exercise, and Military Operations (TEMO), Research, Development, and Acquisition (RDA), and Advanced Concepts and Research (ACR) domains.

2. Identify current use of visualization or visualization related standards.

3. Identify and define visualization products in the Army, Department of Defense (DoD), academia research institutes, and industry. Categorize products in use or under development by the three levels of architecture, deployment and retirement timelines, and domain usage.

4. Assess utility of existing standards. Update inadequate standards and create standards where deficiencies exist.

**PRODUCTS**

1. Visualization Template to establish requirements using off the shelf office software.

2. Developmental Matrix for visualization standards implementation using off the shelf office database software.

**MILESTONES**

| EVENT | DURATION |
|---|---|
| Visualization Team Meeting ICW the Interservice/ Industry Training Systems and Education Conference (I/ITSEC) [x 10 People] | 1 - 4 Dec 97 in Orlando, FL |
| Visualization Team Meeting to Produce Visualization Development Matrix [x 10 People] | 4 Days TBD in Feb/Mar 98 at NSC, Ft. Leavenworth, KS |
| Five Surveying Trips [x 2/3 People] | 2-3 Days TBD FY 98 |

**RISK/BENEFIT ANALYSIS**

Bolstering this plan with additional resources accelerates establishment of visualization standards. Team member participation in conferences and surveying trips to the field, industry, and academia is facilitated by this funding. Failing to offer fiscal relief to participating team member organizations jeopardizes the fidelity of the Visualization Template and Development Matrix which may stall standards implementation.

**EXECUTABILITY**

Building a talented team to define requirements, survey usage, and establish management procedures is prerequisite to engineering useful visualization standards. This plan will be executed to some degree in FY 98 pending available travel funds.

*AMIP-98-CDM-02*

| | |
|---|---|
| **PROJECT TITLE** | **Battle Management Language and Knowledge Representation Standard** |
| **STANDARDS CATEGORY** | Command Decision Modeling |
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## EXECUTIVE SUMMARY

Representing the command and control decision-making process in software is a critical and challenging task confronting the simulation community. To support the sharing and reuse of formally represented knowledge among different decision-making process models and simulations, it is useful to define a common vocabulary in which shared knowledge is represented. This effort will develop a specification of a representational vocabulary and model for a shared domain of discourse -- definitions of classes, relations, functions, and other objects -- an ontology. We will examine the alternatives being used within the M&S community for suitability as an Army standard such as Command and Control Simulation Interface Language (CCSIL), examine the battle management language (BML) contained within the Eagle model, and DARPA's Knowledge Query and Manipulation Language (KQML). The results of this effort can be utilized by simulations such as WARSIM 2000, STOW (CFOR), JWARS, and OneSAF.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. A knowledge representation is most fundamentally a surrogate, a substitute for the thing itself, used to enable an entity to determine consequences by thinking rather than acting, i.e., by reasoning about the world rather than taking action in it.

2. A knowledge representation is also a set of ontological commitments. It is unavoidably so because of the inevitable imperfections of representations. It is usefully so because judicious selection of commitments provide the opportunity to focus attention on aspects of the world we believe to be relevant.

3. To support the sharing and reuse of formally represented knowledge among different decision-making process models and simulations, it is useful to define a common vocabulary in which shared knowledge is represented. This effort will develop a specification of a representational vocabulary and model for a shared domain of discourse --

   definitions of classes, relations, functions, and other objects -- an ontology. An ontology is a specification of a conceptualization.

4. We will be designing an ontology for the purpose of enabling command agent knowledge sharing and reuse within/among models and simulations. For pragmatic reasons, the ontology will be written as a set of definitions of formal vocabulary. Although this isn't the only way to specify a conceptualization, it has some nice properties for knowledge sharing among AI software (e.g., semantics independent of reader and context). Practically, an ontological commitment is an agreement to use a vocabulary (i.e., ask queries and make assertions) in a way that is consistent (but not complete) with respect to the theory specified by an ontology. We build agents that commit to ontologies. We design ontologies so we can share knowledge with and among these agents.

## TECHNICAL APPROACH

1. The ontology designed must deal with both the exchange of operational information in the form of orders and reports as well as supporting the exchange of other command and environmental information which command agents will reason upon.

2. We will examine the alternatives being used within the M&S community for suitability as an Army standard for the exchange of C2 information and plans and orders among simulated command agents/entities and between the agents and the human computer interface. The Command and Control Simulation Interface Language (CCSIL) is one such alternative.

3. The Command and Control Simulation Interface Language (CCSIL) is a special language for communicating between and among command entities (either software or human) and small units of virtual platforms generated by computers for the STOW environment.

4. CCSIL includes a set of messages and a vocabulary of military terms to fill out those messages. It was developed to facilitate interoperability between different implementations of command entities and platform entities (vehicles). CCSIL will be examined to see what extensions should be added to allow higher echelon (above company level) C2 to take place. We will also examine the battle management language (BML) contained within the Eagle model. Although CCSIL has its roots in the Eagle BML, extensions have been added to the Eagle BML that are worth examining.

5. As part of this effort, we also would like to examine the types of data input to, produced by, or output from command agents (e.g., mission, doctrine, commander's intent -- METT-T) to develop a knowledge representational framework that can encapsulate this information so that the simulation command agents can share and reason upon it. Industry and government knowledge representations will be assessed for reuse. One promising candidate for reuse is DARPA's KQML.

6. KQML or the Knowledge Query and Manipulation Language is a language and protocol for exchanging information and knowledge. It is part of a larger effort, DARPA Knowledge Sharing Effort which is aimed at developing techniques and methodology for building large-scale knowledge bases which are sharable and reusable. KQML is both a message format and a message-handling protocol to support run-time knowledge sharing among agents. KQML can be used as a language for an application program to interact with an intelligent system or for two or more intelligent systems to share knowledge in support of cooperative problem solving. KQML focuses on an extensible set of performatives, which defines the permissible operations that agents may attempt on each other's knowledge and goal stores. The performatives comprise a substrate on which to develop higher-level models of inter-agent interaction. In addition, KQML provides a basic architecture for knowledge sharing through a special class of agent called communication facilitators which coordinate the interactions of other agents.

7. We also examine sources such as the Functional Description of the Battlespace (FDB) and the knowledge acquisition work being done for Warfighter's Simulation 2000.

## PRODUCTS

A standardized ontology model and user's guide to facilitate providing operational data in a format such that the computer can reason on it and facilitates encoding of command and planning knowledge which will feed decision support services used by multiple command agents.

## MILESTONES

| | Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Milestone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Conduct Research | x | x | x | | | | | | | | | |
| Build Common Vocabulary | | | x | x | x | x | | | | | | |
| Design Ontology Model | | | | | x | x | x | x | | | | |
| Develop User's Guide | | | | | | | x | x | x | x | | |
| Finalize Results and Deliver Standard | | | | | | | | | | x | x | x |

## RISK/BENEFIT ANALYSIS

The benefit of a standard battle management language and knowledge representation ontology will be realized in the ability of different models and simulations to share and reuse the same knowledge and exchange of operational information. The results of this effort can be utilized by simulations such as WARSIM 2000, STOW (CFOR), JWARS, and OneSAF.

**EXECUTABILITY**

| | |
|---|---|
| Contracts | 90% Existing support contracts with NSC. |
| | 100% of funds will be used for contract support. |
| In-House | 10% NSC, DCSINT, and NGIC Oversight |

*AMIP-98-ACQ-01*

**PROJECT TITLE** | **Calibration of the DELPHI Target Acquisition Model**

**STANDARDS CATEGORY** | Acquire

**POINT OF CONTACT**

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## EXECUTIVE SUMMARY

DELPHI is the sanitized (non-proprietary) version of the British Aerospace ORACLE target acquisition model. DELPHI predicts the ability of human observers to detect, recognize, and identify targets with unaided eye or direct view optics. TRAC-WSMR has investigated replacing the current ACQUIRE model visual target acquisition routines with the ORACLE algorithms and concluded that there was sufficient merit to warrant an effort to develop and calibrate the DELPHI algorithms to US definitions of detection, recognition, and identification. This proposal covers the second year of a two year effort. The first year accomplished algorithm extraction and sanitization. The second year will be dedicated to calibration and finding replacements for algorithms which could not be sanitized. The final report will contain the DELPHI algorithms and calibration results. DELPHI will become a standard algorithm for representing visual target acquisition in combat simulations. The ACQUIRE model will remain the standard for thermal target acquisition.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. ORACLE is a computer model developed by British Aerospace which predicts the ability of human observers to detect, recognize, and identify targets. The U.S. received a scaled down PC version from the UK through a QWG and has received permission to extract the non-proprietary algorithms from this version of ORACLE and rename/repackage them for use in combat simulations. These repackaged algorithms will go by the name of DELPHI and only encompass the visual and direct view optics algorithms.

2. The current methodology for magnified direct view optics (the ACQUIRE model) produces probability predictions which fall from one to zero over an unrealistically short range span. The ORACLE/DELPHI algorithms produce a, more believable, graceful degradation. TRAC-WSMR has investigated replacing the current ACQUIRE model visual target acquisition routines with the ORACLE algorithms and concluded that there was sufficient merit to warrant an effort to develop and calibrate the DELPHI algorithms to US definitions of detection, recognition, and identification.

3. The version of ORACLE provided to the US was calibrated with data not available to the US and "tuned" to a European environment and acquisition task. DELPHI algorithms must be calibrated to match US definitions of detection, recognition, and identification. In

Dr. Lind's (Naval Air Weapons Center & Naval Postgraduate School) verification report on the ORACLE algorithms, she suggests that the following parameters may need recalibration in order to better represent target acquisition in the field:

A. Fractional perimeter for detection, recognition, and identification

B. The slope parameter in the contrast-ratio to probability function which represents observer variability (both within and between)

C. Confidence level - forced-choice or free-choice, tolerance for errors (false alarms/missed targets)

D. There are two visual channels represented in the ORACLE model. The cone midget channel is responsible for the detection of stationary targets while the cone diffuse channel is the primary contributor to the detection of moving targets. This proposal covers the second year of a two year effort. Progress to date from the first years effort include the development of a non-proprietary version of the cone midget channel algorithms and the identification of data sets for calibration. The remainder of the year will be dedicated to developing a non-proprietary version of the diffuse channel algorithm and preparing data sets for calibration.

**TECHNICAL APPROACH**

1. The first step was to extract the non-proprietary ORACLE algorithms. This was completed last year.

2. The second step is to develop suitable replacements for the proprietary algorithms from the open literature. (may be necessary for portions of the diffuse channel algorithm)

3. The third step was to identify sources of data for calibration. The following sources have been identified: Distributed Interactive Simulation Search and Target Acquisition Fidelity (DISSTAF) field test, Summer 94 Target Acquisition Modeling Improvement Program field test, Winter 97 moving target laboratory perception experiment, NVESD's August 96 target acquisition under flare illumination experiment, and a Dutch laboratory perception experiment based on DISSTAF imagery. These data sources include stationary and moving targets; unaided eye and magnified optics; field-of-view and field-of-regard search; high and low light levels; and target detection, recognition, and identification. These data sets are currently being analyzed and prepared for the calibration process.

4. The fourth step is to calibrate the DELPHI algorithms. First the midget channel (stationary target) algorithms and then the diffuse channel (moving target) algorithms. The three parameters identified by Dr. Lind will be calibrated along with any additional parameters identified during the algorithm extraction and development process.

5. Since DELPHI will be a complex set of algorithms, it is appropriate to implement it as an HLA federate for use in high resolution combat simulations such as CASTFOREM,

ModSAF, and OneSAF. A detailed plan for HLA compliance will be developed and used in the coding and implementation of the DELPHI algorithms.

6. The Army's target acquisition modeling community, ACQSIM will be used as a source for critical review of the analysis. Members of ACQSIM include NVESD, TRAC-WSMR, ARL, AMSAA, IDA, and TACOM.

## PRODUCTS

1. Final report detailing the DELPHI algorithms and calibration (methodology used, results, and lessons learned).

2. A draft standard for Standard Category Acquire covering the DELPHI model algorithms.

3. A methodology which can be applied to future data sets to determine if the calibration needs to be modified.

## MILESTONES

| Task | Completion |
|---|---|
| Coded midget channel algorithms | 1Qtr FY98 |
| Detailed plan for HLA compliance | 1Qtr FY98 |
| Calibration of midget channel algorithm | 2Qtr FY98 |
| Coded diffuse channel algorithms | 2Qtr FY98 |
| Calibration diffuse channel algorithms | 3Qtr FY98 |
| Report | 4Qtr FY98 |

## RISK/BENEFIT ANALYSIS

1. Use of the DELPHI algorithms will improve the representation of target acquisition in combat simulations.

2. This project will have developed techniques for assessing the suitability of DELPHI calibrations. These techniques can be applied to future data sets to assess the appropriateness of the current calibration to represent additional situations.

3. The completion of this effort will provide an Acquire standard representation for visual perception.

## EXECUTABILITY

All work will be performed at government facilities at AMSAA, TRAC-WSMR, or the Naval Postgraduate School, Monterey, CA.

*AMIP-98-DATA-01*

| | | |
|---|---|---|
| **PROJECT TITLE** | **Characteristics and Performance (C&P) Data Interchange Format (DIF) Development** | |
| **STANDARDS CATEGORY** | Data | |
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## EXECUTIVE SUMMARY

In an effort to provide a framework for the development and automation of databases and standardization of data infrastructures, a data interchange format (DIF) for characteristics and performance (C&P) data is required. Currently, the Defense Modeling and Simulation Office (DMSO) is sponsoring the development of an Order of Battle DIF, Modular Reconfigurable C4I Interface (MRCI) DIF, and the Synthetic Environments Data Representation and Integration Specification (SEDRIS) project. This effort will focus on characterizing C&P data. This will be accomplished by reviewing several existing data models from both producers and consumers. Where necessary, the databases will be reverse engineered and a common data model will be developed as required. The resulting DIF, data model and data dictionary will be prepared as a data standardization proposal package for presentation to the DoD Data Administrator.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. In order to appreciate the value of data interchange formats and their application to the establishments of data standards, a brief discussion of database management considerations is essential.

2. Until quite recently, databases supporting computer programs were simply collections of data values made available through various media, then accessed and applied only by the using software. This management approach necessitated laborious preparation and maintenance of data values, with little or no advantage from automation. The predictable outcomes were high costs, numerous errors, and adverse impact on the results obtained

through computer applications in general.

3. In effect, the data had no life outside the using program. Therefore, application programs were required to perform data quality functions in their programs right along with the essential functions of the program. This process occurs each time the program is run and results in excessive duplication of effort and different interpretations of how to correct the data.

4. Widespread realization of the inefficiency of this situation resulted in the advent of general purpose database management systems. These systems afforded the full leverage of computer automation to the task of preparing and maintaining data for multiple software application programs. They established common (standard) representations and enforced pertinent rules regarding allowable values and agreed-upon relationships among the values. At last the data could remain alive outside of the using programs.

5. Even greater reliability, efficiency and portability of database designs and implementations was realized with the introduction of technically rigorous, standardized data modeling.

6. Data interchange formats rely on data models to develop data standards that can be used to effectively and efficiently transfer data between data producers and data consumers. They provide a standard view of the area of interest through a data model of the subject area of interest (SAI) and the use of common semantics and syntax to facilitate communication and understanding. A mapping function that translates from the consumer's lexicon to the standard lexicon and from the standard lexicon to the producer's lexicon are also incorporated. Through this process the consumer can request data from a producer in the consumer's native language. The figure below shows the value of data standards and the DIF. With five databases and no standards, 20 transformations are required. With standards, only ten are needed. This advantage grows rapidly as more data sources are considered. This concept also allows existing databases to continue to function without alteration and provides a standardized construct for designing new databases.

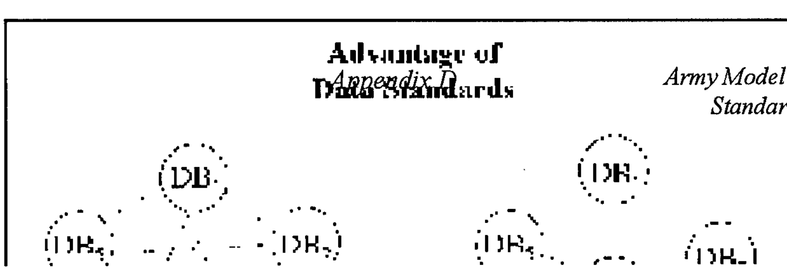

Figure 1. Advantage of sharing data through a standard

**TECHNICAL APPROACH**

The C&P area is very broad and complex. The first step of the task will be to plan the scope and document the plan of attack. Next the data sources (and their associated subject matter experts (SMEs) ) within that scope will be identified. A series of meetings will be held between the SMEs, repository administrators and the data modelers to gather the information needed to develop the SAI models and the mapping functions. Then, the SAI models and mapping functions will be built and reviewed. This is a critical step since the SAI model is the centerpiece of the standardization effort and the mapping function acts as a translator between the consumer and producer. The software development, testing and deployment tasks associated with the C&P effort are follow-on efforts.

**PRODUCTS**

The products from this effort are:

1. Document detailing the DIF development approach and scope
2. Lists of data sets and sources for each subject area of interest
3. Standard subject area of interest models
4. Mapping functions
5. Final report describing accomplishments and follow-on efforts
6. Data standardization proposal packages

**MILESTONES**

| | |
|---|---|
| Source Lists | Dec 1997 |
| Plan of Attack | Feb 1998 |
| SAI Models | May 1998 |
| Mapping Functions | Aug 1998 |
| Final Report | Sep 1998 |

**RISK/BENEFIT ANALYSIS**

1. The technical risks associated with developing the C&P DIF are rooted in the inherent complexity of complex performance data. The process of creating a DIF and the tools for doing so have been tested and fine tuned during the generation of other DIFS by DMSO. This experience and DMSO provided expertise lower the risk associated with this project. There are also two competing risks inherent in managing this project. To achieve true standardization, all players must be represented during the development of the SAI model and the mapping functions. However, if all players are involved, the complexity of the task increases greatly. The approach identified here tries to strike a balance between the two risks by including a few players with the expertise to cover a large spectrum of the M&S community. This will lower the risk of omitting items from the model while keeping the group to a manageable size.

2. The benefits of this project are standardization and re-use of C&P data among Army and Joint M&S organizations. These standards can be applied to new data systems to make a seamless network of composable solutions.

**EXECUTABILITY**

The work will be performed the Army with support from DMSO. DMSO provided support (funded by DMSO) will include expertise in building the subject area of interest models, reverse engineering of existing databases, and data standardization submissions.

*AMIP-98-LOG-01*

**PROJECT TITLE** **Combat Service Support (CSS) Core Representation**

**STANDARDS CATEGORY** Logistics

**POINT OF CONTACT**

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## EXECUTIVE SUMMARY

The development, evaluation, analysis, and training of new concepts, policies and doctrine requires decision support tools with the capability to fully represent and simulate the logistical requirements of a United States Army force operating in Major Regional Conflicts (MRC), Local Regional Conflicts (LRC), or other contingencies. The development of such tools requires the identification of the minimum essential combat service support (CSS) functionality needed in any model or simulation to support the combat, combat support, and combat service support community. There is currently no automated program or data base that can rapidly and accurately, identify and describe in detail what the essential CSS requirements are that should be portrayed in a model or simulation. As a result of this failing, models and simulations are developed without any CSS representation or at best, a very poor portrayal. This proposed project will use the Functional Description of the Battlespace (FDB) program to identify, record, and automate those CSS functions that must be included in all future models and simulations in order to develop a balanced force for Force XXI and Army After Next. The FDB is a simulation-independent data repository system currently under development by STRICOM and the National Simulation Center (NSC). The FDB is designed to meet the needs of simulation builders in the collection of validated, standard descriptions of battlefield functions, physical algorithms, equipment characteristics, and terrain data. The identification of the CSS functions (with all associated data) and recording these in the FDB, will provide the model/simulation developer with needed and validated information to build the correct decision support tool needed by Army planners.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. The development of new concepts and materiel for FORCE XXI and the Army of the future, requires analytical tools that can represent a wide range of logistics concepts to support logistics systems, subsystems, units, supply support activities, resources, and transportation assets. These concepts include movement, storage, distribution, and evacuation of supplies and equipment from the Port of debarkation (POD) to the foxhole over all lines of communication (land, water, air). Development of such tools requires the

identification of the core CSS functions that the model developer must portray in any Army simulation.

2. The USA CASCOM has established a Model and Simulation Integrated Concept Team (M&S ICT) to identify the shortfalls in this area and develop a process for correcting this deficiency. The M&S ICT, composed of numerous DA Agencies, has identified the FDB as the process to be used in the correction of this problem. Use of the FDB will provide the model developer with a standardized and validated data base of the core CSS representation that is required in any Army model or simulation.

## TECHNICAL APPROACH

1. The FDB should be expanded to include the minimum essential core CSS representation that is required in any Army model or simulation. The FDB is a simulation-independent data repository system being developed jointly by STRICOM and NSC. The primary objective of the FDB is to gather, organize, automate, manage, and disseminate battlespace information. It describes the physical environment, systems and materiel, human characteristics, organization, doctrine and process, and the interactions between these data.

2. The data contained in the FDB are driven by tasks and are described in detail using the FDB Task Process Descriptions (TPD). The purpose of the TPD is to impose a standard method of describing all the tasks (functions) that are performed during any type of military operation. The TPD consists of ten parts: the task description, the associated tasks, the input required, the time to complete, the output provided, supporting objects, resources, references, and associated code and simulation algorithms. The TPD's are developed through the use of Subject Matter Experts (SME's) working with an object modeler/systems expert.

3. During this time of declining resources, action officers are required to do more, faster, and with greater accuracy. The Army has a need for decision support tools that will support the CSS action officer in the accomplishment of those duties. In order to provide these type of tools, it is essential that these models and simulations include the minimum essential CSS representation. Populating the FDB with standard CSS processes will help insure that the CSS functionality is identified, validated, and available to the model developer. The following are the CSS areas that must be included in the FDB, in order of priority:

   A. Supply
   B. Sustainment
   C. Arm
   D. Fix
   E. Move

F. Services
G. Medical
H. Personnel

## PRODUCTS

FDB will provide the Army with a data base containing the minimum essential core CSS representation needed to simulate the CSS requirements of a United States Army force operating in Major Regional Conflicts (MRC), Local Regional Conflicts (LRC), or other contingencies. This product will include all the data required by the TPD in order to populate the FDB with the core CSS representation.

## MILESTONES

This project is proposed as a twelve month effort; a tentative milestone schedule is:

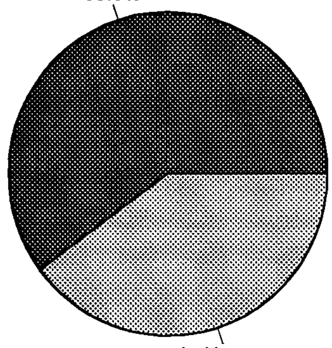
| MILESTONES | MONTHS FROM START OF TASK |
|---|---|
| Task Plan | 1 |
| Design Specification | 2 |
| SME Input | 3 |
| Draft TPD's | 10 |
| Draft Reports | 11 |
| Final TPD's, Reports | 12 |

## RISK/BENEFIT ANALYSIS

This is a low risk project that takes maximum advantage of an existing and proven program developed jointly by STRICOM and NSC.

**EXECUTABILITY**

This will be a joint effort between the United States Army CASCOM and a contractor. As VEDA, Inc is currently developing the FDB for NSC, it is anticipated that this effort could be an extension of that contract.



*AMIP-98-CDM-01*

| | |
|---|---|
| **PROJECT TITLE** | **Command Planning Process Standard** |
| **STANDARDS CATEGORY** | Command Decision Modeling |
| **POINTS OF CONTACT** | National Simulation Center & STRICOM<br>Sean MacKinnon \ Barbara Pemberton<br>Com: (913) 684-8290 DSN: 552-8290 \ (407) 384-3847<br>410 Kearny Avenue \ 12350 Research Parkway<br>Fort Leavenworth, KS 66027 \ Orlando, FL 32826<br>Fax: (913) 684-8299 \ (407) 384-3830<br><br>pembertb@stricom.army.mil |

**EXECUTIVE SUMMARY**

Representing the command and control decision-making process in software is a critical and challenging task confronting the simulation community. Given this general statement, there is a need for standard proven algorithms to represent the staff planning process. One such set of algorithms comprise the "Adversarial Planner". A normative standard will be developed for the M&S community using Adversarial Planner as the basis for the standard. Documentation and user guides will be produced that will allow reuse as an application independent standard for automated multi-echelon plan cascading that accounts for multi-agent coordination, the adversary's counterplans, plan execution monitoring, replanning, and plan repair. The results of this effort can be utilized by simulations such as WARSIM 2000, STOW (CFOR), JWARS, and OneSAF.

**BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM**

1. Simulated inter-command coordination and multi-layer plan cascading are needed if future simulations such as WARSIM 2000, STOW (CFOR), JWARS, and OneSAF are to achieve their goals. This effort will standardize the algorithms in the Adversarial Planner (AP) which provides this capability.

2. A key concept underlying modern battlefield simulation is modeling of military operations from the perspective of battle command. Course of action (COA) planning develops synchronized sequences of activities assigned to subordinate units to accomplish specified and implied tasks of a higher command's operations order. This is called "plan cascading". An automated planner can work out detailed operations to be executed by simulated units several echelons below the level of the training or analysis problem. This allows higher fidelity simulations without the need for tedious specification of simulation scripts.

3. AP, or the Adversarial Planner, is an artificial intelligence program that provides plan generation, execution monitoring, and replanning in multi-agent adversarial domains. Eagle is a multi-echelon battle simulation based on the concept of modeling the command estimate process currently in use by the U.S. Army. Together, Eagle and AP allow the user of the system to specify an operations order for a division, and AP automatically generates detailed plans for battalion-level resolution units. During simulation execution,

AP gets situation and spot reports from Eagle and controls execution and replanning if necessary.

## TECHNICAL APPROACH

The command planning model is realized in the AP software which is integrated with the Eagle combat simulation and resides in the WARSIM 2000 testbed. However, as it currently exists AP is tied to Eagle as an application and is coded in legacy software (LISP). This effort will take the AP algorithms which represent the staff planning process and document them in a fashion similar to a Backus Naur Form (language syntax) which will allow ease of reuse to the community. Currently, AP is tied to Eagle. As such, AP is not in a user friendly format nor in a user friendly simulation. In order to view and utilize the AP LISP software, one must invest heavily in technology and software licenses ($50k-$70k). By providing a through users guide to the algorithms and planning model, AP can easily be recoded in other simulations.

## PRODUCTS

1. The primary product of this research will be a standard model of battle planning that can represent coordinated planning between commands and echelons. This will allow simulations to achieve multilevel plan cascading and interplan coordination. A working model of AP will be developed (PC based) so that the user can gain full appreciation of what AP does for planning.

2. Documentation and user guides will be produced that will allow reuse as an application independent standard for automated multi-echelon plan cascading that accounts for multi-agent coordination, the adversary's counterplans, plan execution monitoring, replanning, and plan repair.

## MILESTONES

| | Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Milestone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| AP-Eagle Review | x | x | x | | | | | | | | | |
| Extract and Develop Std IN BN | | | x | x | x | x | x | x | | | | |
| Produce Documentation | | | | | | | x | x | x | x | x | |
| Finalize and Deliver Normative Standard | | | | | | | | | | | x | x |

## RISK/BENEFIT ANALYSIS

The benefit of the proposed research would be more realistic command and control simulation and the ability for battlefield simulations to perform multilayer plan cascading. The results of this effort can be utilized by simulations such as WARSIM 2000, STOW (CFOR), JWARS, and OneSAF.

## EXECUTABILITY

| | | |
|---|---|---|
| Contracts | 60% | Existing support contracts with MITRE. |
| | 30% | WARSIM LMIS Testbed. |
| In-House | 10% | NSC & STRICOM Oversight |

*AMIP-98-C3-01*

**PROJECT TITLE** **Communication Data Generation**

**STANDARDS CATEGORY** C3 Systems

**POINT OF CONTACTS**


| USA TRAC | USA SIGCEN | USA CECOM |
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**EXECUTIVE SUMMARY**


The Army has been expanding its M&S capabilities to incorporate Information Operations and its impact on the continuum of operations from Low Spectrum of Conflict (LSOC) to war. The initial step in this process for models is the same as the Army is doing in the real world - adding the information infrastructure. This translated into improving the representations of communications in the TRADOC Analysis Center (TRAC) combat models. TRAC worked with U.S. Army Communications And Electronics Command (CECOM) and U.S. Army Signal Center (SIGCEN) to develop and refine these comms representations. TRAC is ready to apply these new representations, but CECOM and SIGCEN do not have the data for the variety of organizations, time frames and theaters of operations needed by TRAC.

OPNET has been chosen by CECOM, SIGCEN, as well as others in the communications M&S community, as the Army's future comms modeling environment. This environment will be used to conduct technical analyses of C4I system/network performance required for supporting the development and refinement of the Army's Technical and Systems Architectures and for analyzing operational issues of Command, Control, Communications, Computers (C4) network/system performance in support of the development and validation of the Army's Operational Architecture. TRAC has entered an agreement to partner with CECOM and SIGCEN resulting in improved model fidelity sensitive to the impacts of communications. Accordingly, TRAC is developing an OPNET capability to be interoperable with CECOM and SIGCEN.

Funding is needed for CECOM to develop the engineering-level OPNET modules required by SIGCEN to develop the OPNET network model that can provide an initial set of comms data for TRAC's combat simulations. The results will begin to establish the principles of best practice and serve as the basis for future model efforts. Products from this effort will be an initial step towards developing a repository of Army approved networks, nodes, and processes.

**BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM**

1. TRAC has the responsibility to perform credible operations analysis which requires accurate portrayal of information and communication systems within TRAC's force-on-force models.

2. CECOM has ongoing efforts to evolve and enhance the CECOM System Performance Model (SPM) to support analyses of the Technical and Systems Architectures required for the digitized battlefield.

3. SIGCEN is currently developing a modeling plan to modernize it's ability to support its mission of developing information systems requirements and analyzing systems architecture ability to support the warfighter. The tool chosen is OPNET.

4. Currently TRAC has made the first step towards a more accurate representation of communications in it's combat models by working closely with CECOM and SIGCEN to develop and refine a communications infrastructure in the Vector-in-Commander (VIC) model. At this time, data for these representations do not exist for the array of organizations, time frames, and theaters of operation required by TRAC, but could be created with the assistance of the Army Model Improvement Program utilizing OPNET, the emerging standard for Comms M&S.

5. An MOA has been staffed between the three organizations which is intended to create an M&S environment appropriate to analyze the operational, system and technical aspects of C4 systems, to validate the operational architecture (OA) and to measure the effects of communications design and engineering (CECOM) and operational loading (SIGCEN) on the outcome of warfighting operations (TRAC). This objective is consistent with the goals of the *Army Enterprise Implementation Plan,* Task 9 Action Plan, which specifies the use of Department of Defense (DoD)-compliant tools and methodologies in the prioritization and integration of C4 models needed to facilitate trade-off analyses and validation of the Operational, Systems and Technical Architectures and to support the efforts of the Architecture Control Committee.

6. OPNET is the current choice for the Army's future communications environment and simulation tool and is being recommend as the Army M&S standard by the C3 Systems SCC. CECOM and the SIGCEN recently established an OPNET capability and have initiated their OPNET-based projects TRAC is currently in the process of establishing an OPNET as a performance tool to generate communications data for its force-on-force models. This project will adhere to the Army M&S comms by using CECOM developed communications nodes and processes with SIGCEN established network structures and operational loading. OPNET provides the environment and tool that allows this standardization that can trace the comms data and representations in TRAC's force-on-force models through SIGCEN's operational models down to CECOM's engineering-level models.

## TECHNICAL APPROACH

1. TRAC recently implemented a nodal network in its force-on-force VIC, where the multiple arcs on the network portray the different communications links (modes) between various military units (nodes). Each arc represents a specific type of communications component/system (i.e., ELPRS, SINCGARS,...) and each has an associated time to transmit a particular report type along with a probability of successful transmission. Each arc between units may actually be multiple links depending on the number of communications modes available in those particular units. For this reason TRAC has implemented a prioritized list of communications modes for each pair of units required to exchange information. The model will sequentially try to send a message across each of the modes in the list until either there is a success, or the message falls into a queue for later transmission due the fact that all modes were closed at that time. Each arc can be subject to a variety of degradation factors such as atmospherics, terrain, jamming, combat status, etc. Each message has an associated stale time, after which the model will no longer try to send it.

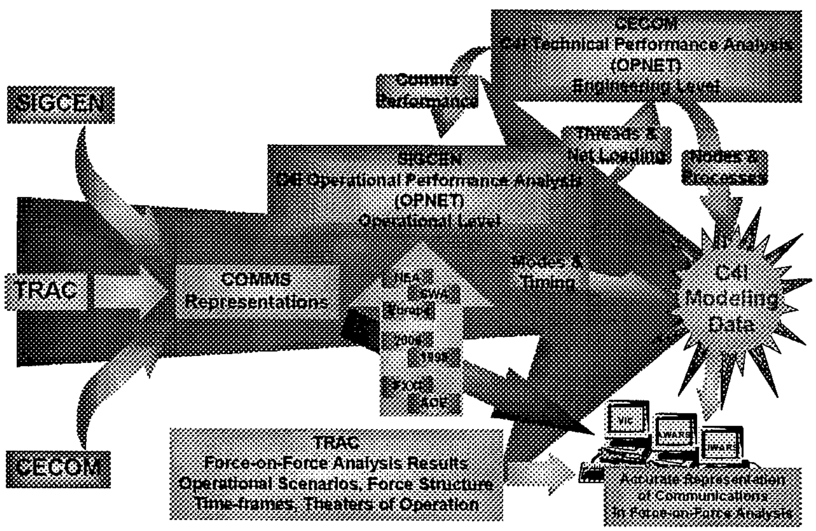



**Figure 1. Data Generation Methodology**

2. During the execution of this proposal (Figure 1), TRAC will provide operational level scenario databases as well as their accompanying documentation from TRADOC approved scenarios. This includes the formulation and passing of such information as mission events, activities, and actions, as well as terrain profiles, and location/movement of units to support SIGCEN efforts to develop detailed information about scenario and operational loading. In addition to the scenario information, TRAC will be responsible for supplying a list of report types used in its models and force structure information for both friendly and enemy forces, specified theaters, and time frames. CECOM will develop the engineering level data (in the form of OPNET process and node libraries) required by SIGCEN to develop and exercise their networks in OPNET for the time frames, force

structures, and theaters of operation needed by TRAC.

3. Utilizing OPNET, the SIGCEN will create models implementing information from TRAC and CECOM, and analyze the performance of the networks among units. Analysis of the comms traffic data will produce a standardized description of the set of statistical tables/databases that can be used to represent loading on the systems. Common understanding by SIGCEN/ CECOM/ TRAC will provide the ability to use the results of all three levels of modeling methodologies. TRAC requires the following comms data:

   A. Communication system/modes available to each pair of units needing to exchange information, in prioritized order.

   B. Expected message transfer time of each report type for each communication mode. This time should be a function of network loading, taking into account messages that are not explicitly modeled, but may be utilizing network bandwidth.

   C. Probability of successful transmission and receipt of each report type for each communication mode.

**PRODUCTS**

1. TRAC will provide scenario databases, report type information, friendly and enemy force structures, specific theaters and time-frames as well as the resulting force effectiveness from their force-on-force analyses.

2. The SIGCEN will provide OPNET networks for the force structures, specific theaters and time-frames of interest along with the communication modes and associated report transfer times as well as any other insights derived from their analysis of battlefield networks. The resulting networks will be placed in a repository for future use. SIGCEN will develop process and node data to support traffic loading and system laydown which will result in the networks for the repository.

3. CECOM will develop specific detailed OPNET process and node data to drive the network analysis conducted by SIGCEN. The resulting process and node data will also be placed in a repository for reuse. Based upon the interaction between the three organizations the following products will emerge:

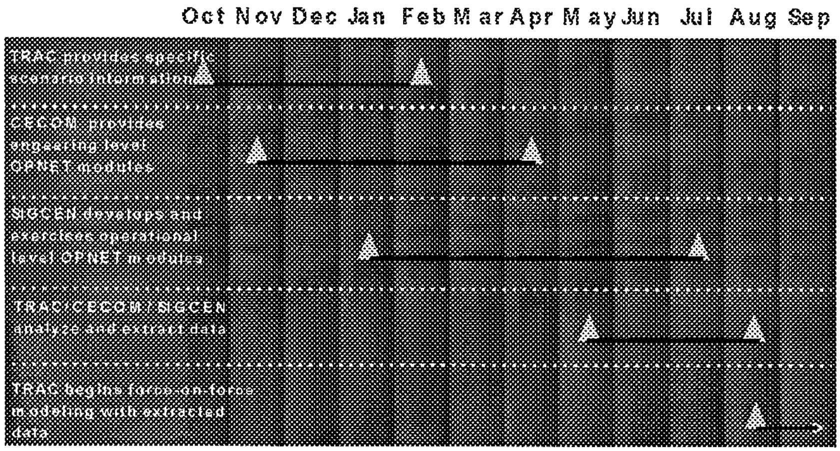
   A. A consolidated list of communication modes and transfer times as detailed in the previous section.

   B. A more comprehensive module library, containing current and future communication technology.

   C. An initial step towards developing a repository of Army approved networks , nodes, and processes.

## MILESTONES

Figure 2 contains timelines for execution of the project. The initial phase is the construction




of the OPNET modules for Army comms systems required by SIGCEN for the development of OPNET network models for the force structures, specific theaters and time-frames of interest. This will include involvement from all three organizations. Over the course of the next 6 months, SIGCEN will develop these models, combine them as appropriate, and make the performance data runs. Data required by TRAC will be extracted from these runs and statistically summarized for inclusion in TRAC's force-on-force communications representations for determining force effectiveness under a variety of conditions.

## RISK/BENEFIT ANALYSIS

This is a low risk venture with high payoff. Information Operations (IO) is probably the most neglected area of analysis. By getting a handle on the flow of information across the battlefield, we have taken a significant leap to reducing the uncertainty surrounding IO. There are studies being conducted today in TRAC that would benefit from the availability of this data if it existed (e.g., Force XXI Division Design Analysis and J6 Sensor to Shooter (Battle Management) Study). The architecture is there, but it requires the data. The production of this data will involve the use of the Army's standard communications modeling tool, OPNET, and will result in a repository of standard OPNET modules to be used in the construction of a nearly unlimited number of communication configurations.

## EXECUTABILITY

TRAC intends to provide ½ of a professional staff year (PSY) for this effort during FY98, all of which will be funded in-house (Figure 3). The requested funds will be divided equally between the SIGCEN and CECOM. Both the SIGCEN and CECOM will provide in-house funding with their AMIP funds being applied to existing contracts. AMIP OPA funds have also been requested by the SIGCEN to purchase additional hardware required to complete the effort.

*AMIP-98-ATTR-01*

**PROJECT TITLE** **Compendium of Aggregate Level Attrition Algorithms**
(Pending Funding Availability)

**STANDARDS CATEGORY** Attrition

**POINT OF CONTACT**
US Army Materiel Systems Analysis Activity
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## EXECUTIVE SUMMARY

In October 1996, the Attrition Working Group published the "Compendium of High Resolution Attrition Algorithms" as AMSAA Special Publication No. 77. This proposal calls for the publication of a companion document titled "Compendium of Aggregate Level Attrition Algorithms." AMSAA has already initiated the development of a document to support attrition standards development at the aggregate level. Work on this document has focused on ground-to-ground direct fire attrition processes. A first draft of this focused effort will be completed during FY 97 using mission funding.

The expansion of this draft will be a joint effort among AMSAA, TRAC-FLVN (the TRAC element at Ft. Leavenworth, KS), and the Concepts Analysis Agency (CAA); with AMSAA serving as the overall project lead and coordinator. A draft of the entire compendium will be produced, and the initial review will be accomplished by the end of FY 98. Additional reviews and modifications will be completed in the first quarter of FY 99, with the final document published during the second quarter of FY 99. These attrition algorithms would then be proposed as the standard for use in developing future aggregate level simulations for distributed environments.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. In early 1994, the US Army TRADOC Analysis Center (TRAC) began leading a multi-service, multi-agency project, funded in part by the Defense Modeling and Simulation Office (DMSO). The purpose was to establish verification, validation, and accreditation (VV&A) processes, methodologies, and tools. If successful, the project would improve the success rate of distributed interactive simulation (DIS) exercises while providing guidance to and reducing the burden on those actually performing VV&A of distributed simulations. Of the nine tasks defined for the first year of the project, the second of these was to establish processes to VV&A the algorithms used in the various simulations linked in a distributed system. Much work in defining standard attrition algorithms had already been accomplished by AMSAA and TRAC-WSMR (the TRAC element at White Sands Missile Range, NM). Therefore, AMSAA offered to head the Attrition Working Group. This group, in turn, decided to divide its task into establish ing

high resolution attrition algorithm standards and aggregate level attrition algorithm standards. The "Compendium of High Resolution Attrition Algorithms" was published in October 1996 as AMSAA Special Publication No. 77. The purpose of this proposal is to publish a companion document to provide a collection of standard attrition algorithms for aggregate level combat modeling. These attrition algorithms would be proposed as the standard for use in developing future aggregate level simulations for distributed environments.

2. Recent efforts to link diverse models and simulations in a distributed interactive system composed of soldier-in-the-loop virtual simulators, constructive simulation models, and, in some cases, real field exercises have underlined the importance of consistent or at least compatible representations of model processes across the various connected models. A distributed interactive simulation system which shows one weapon system differing greatly in effectiveness from identical or similar weapon systems played in the same exercise by other simulators/simulations would neither be fair to the proponents of the particular systems nor give any soldiers undergoing training a proper feel for relative system performance.

## TECHNICAL APPROACH

1. AMSAA has already initiated the development of the companion document to support attrition standards development at the aggregate level. Work on this document has been focused on ground-to-ground direct fire attrition processes. A first draft of this direct fire portion of the Aggregate Level Compendium will be completed during FY 97 using mission funding.

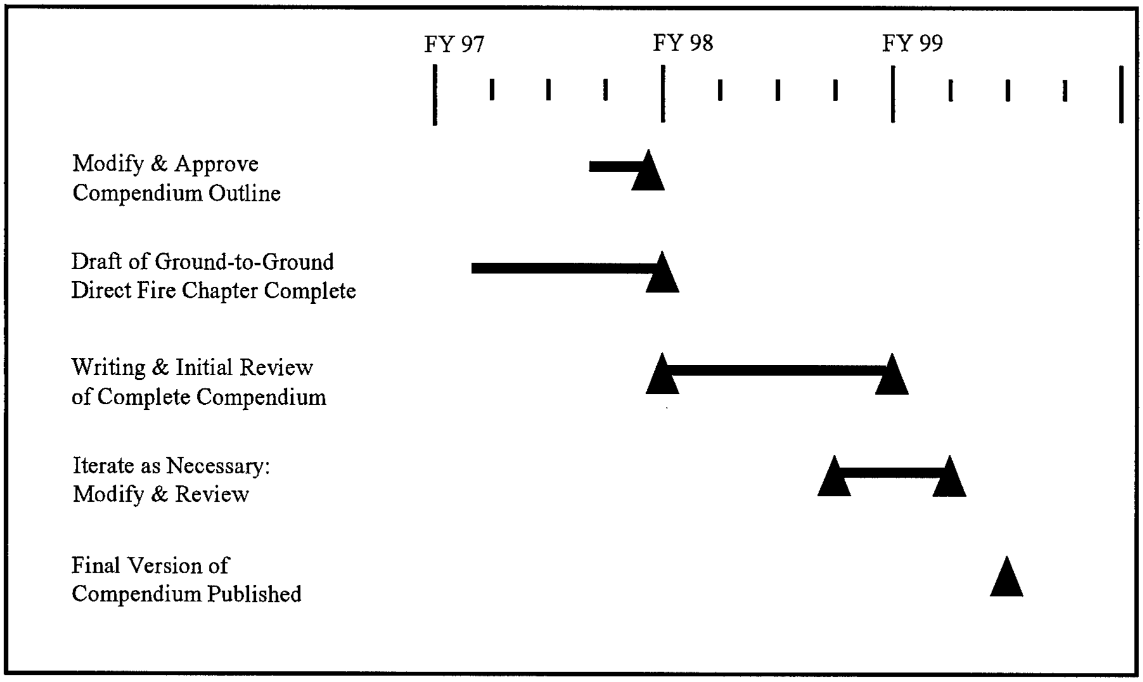
2. This proposal calls for the expansion of the AMSAA effort in ground-to-ground direct fire attrition to all forms of aggregate level attrition including ground-to-air direct fire, air-to-ground direct fire, air-to-air, indirect fire, minefield attrition, and attrition due to reliability failures.

3. It is anticipated this will be a joint effort among, AMSAA, TRAC-FLVN, and the Concepts Analysis Agency . AMSAA will write the portions of the various chapters documenting algorithms used in the AMSAA Division Level (DIVLEV) wargame simulation along with much of the chapter on air-to-air attrition and serve as the overall project lead and coordinator. TRAC-FLVN will provide appropriate chapter portions for the Vector-In-Commander (VIC) and EAGLE division/corps level simulations, while CAA will provide similar information for the Combat Evaluation Model (CEM) and Force Evaluation Model (FORCEM) theater level simulations. Documentation will also encompass any pre-processor models and how these resultant data are used in the larger, main simulations. In addition, a discussion will be provided on factors which combine to influence the attrition process, including such things as line-of-sight, target acquisition, suppression, and weapon positioning.

## PRODUCTS

A complete draft of the entire compendium will be produced, and the initial review will be accomplished by the end of FY 98. Additional reviews and modifications will be completed in the first quarter of FY 99, with the final document published during the second quarter of FY 99.

## MILESTONES




## RISK/BENEFIT ANALYSIS

There are three major benefits to be derived from establishing a collection of standard algorithms for representing attrition (or, indeed, any battlespace process) in aggregate level combat simulations:

1. **Enforcing model consistency**. If all aggregate level models linked in a distributed simulation treat attrition using the same algorithms and use the same performance data, then the probability of consistent weapon system performance from model to model is increased.

2. **Supporting verification and validation**. If the team performing verification and validation of a model or simulation to be linked into a distributed simulation system has a set of objective algorithm standards against which to compare the algorithms implemented in the subject model, then the results of their examination will depend less on the subjective opinions of the team members and more on the quality of the model.

3. **Supporting model development**. If developers of models and simulations to be used in

distributed environments have a collection of algorithms that are known and accepted in the modeling community, then less effort need be wasted attempting to invent what has already been done, and the probability of producing an unacceptable model is reduced.

**EXECUTABILITY**

1. It is proposed that any funding received for this project be allocated to organizations as follows:

| | |
|---|---|
| AMSAA | 20% |
| TRAC-FLVN | 40% |
| CAA | 40% |

2. There will be no need for contractor support in order to complete this project. It will be completed by AMSAA, TRAC-FLVN and CAA personnel.

*AMIP-98-SAF-02*

**PROJECT TITLE** — **Development of a preprocessing tool for Modular Semi-Automated Forces (ModSAF)**

**STANDARDS CATEGORY** — Semi-Automated Forces

**POINT OF CONTACT**

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## EXECUTIVE SUMMARY

In order to facilitate the creation of new vehicles and units, and change ModSAF data via a friendly graphical user's interface (GUI), a preprocessing tool should be developed. Traditionally, persons knowledgeable of ModSAF's software architecture are the ones who have this capability. This tool would give any ModSAF user that capability and help the modeling and simulation domains meet their objectives at a lower cost.

ONESAF is the next generation semi-automated forces (SAF). It has a requirement to have the functionality stated above. ModSAF is a good candidate for establishing a platform for this preprocessing tool's capability, since OneSAF will not be available until 2001-2003. The preprocessor software will be provided to the OneSAF M&S proponent.

The following objectives of the modeling and simulation domains will be met now in ModSAF and in the future with ONESAF by this preprocessing tool: for the RDA domain it will support the trade off analysis for force modernization, for the ACR domain it will support concept exploration of future systems, and for the TEMO domain it will simplify configuration changes needed for training and exercises.

TRAC requests funds to implement a preprocessing tool in ModSAF, prepare the associated code and documentation, and prepare a software change package for inclusion in the next ModSAF baseline release.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. The users of a SAF capability are faced with the need to add new vehicle and unit representation in its software as the Army changes its force structure to effectively meet the objectives of its mission. With ONESAF being the Army's choice of SAF capability in the near-term future, a preprocessing tool with the functionality to add new vehicles, units, and manipulate the data that represents them will benefit ONESAF's user community. This tool should have a user-friendly interface that eliminates the need to have knowledge of how the data is organized. The structure of the ModSAF GUI will provide the framework for this preprocessor's GUI.

2. Since ONESAF is in the planning stages and does not exist as a set of software modules and application programs, ModSAF would serve as a good basis for building this pre-processing tool. The ModSAF platform will provide the best opportunity for transfer to ONESAF.

3. ModSAF is a set of software modules and application programs that permits a single operator to control a large number of vehicles on the virtual battlefield. These vehicles may be controlled individually or as units. ModSAF's open architecture allows its users to add new vehicles or configure existing vehicles into new units. No tool exists for making these processes possible at a high-level. Programming experience with the model is the way to accomplish this.

4. ModSAF is also data-driven. Every vehicle is represented by parameter files, known as reader files (extension .rdr). The interface to add a new vehicle could be extended to manipulate the data of existing vehicles. This tool could be useful to the users involved in verifying vehicle data accuracy as part of the VV&A process. It could also be useful to those involved in activities that require varying parameters.

## TECHNICAL APPROACH

The technical approach for the project is as follows:

1. Write and debug source code to allow user to add new vehicles, add new units, or edit data.
    a. Write source code that will create new params.rdr files for newly created vehicles.
    b. Write source code that will modify existing rdr files that are necessary to make new vehicles/units functional.
    c. Write source code that will modify parameters for existing rdr files for editing data.
2. Write and debug source code to access on-line help.
3. Build and link GUI to source code written in 1 and 2.
4. Test the implementation in ModSAF.
    a. Build a new vehicle via the GUI.
    b. Build a new unit via the GUI.
    c. Change a vehicle's parameters via the GUI and test for changes in ModSAF.
    d. V&V the edited data. Make sure the new code does not cause errors in other ModSAF data.
5. Document the resulting code.
6. Prepare a submittal package for consideration for inclusion in the ModSAF baseline.
7. Provide a submittal package to OneSAF M&S proponents.

## PRODUCTS

1. Source and executable code.

2. Submittal package for inclusion into ModSAF baseline.

**MILESTONES**

| 1. Graphics | 2. Linkages to ModSAF's data files | 3. Testing | 4. Documentation | 5. Integration into baseline |
|---|---|---|---|---|
| 3 months | 2 months | 1 month | 1 month | 1 month |

Work will be completed one year after receipt of AMIP funds.

**RISK/BENEFIT ANALYSIS**

1. These implementations would provide the following benefits to the Army:

   A. Provide the ModSAF user an interface to add a new vehicle or unit for concept evaluation.
   B. Provide the ModSAF user an interface to tweak data during concept evaluation.
   C. Provide a friendly viewing interface of ModSAF data for the VV&A process.

2. Support to Standardization Objectives. Standardization objectives for CGF are outlined in the 1998 CGF report. These are shown below.

   A. Develop valid behavioral, data, and physical model standards for use in OneSAF.
   B. Develop CGF standards that are useful in all M&S domains, applicable to distributed simulations, representative from single entity to corps, and useful in a joint environment.
   C. Minimize operator overhead for CGF.
   D. Ensure structures and data bases are modular and easily isolated.
   E. Provide consistent representations for battle field systems, and unit tactical/doctrinal behaviors in all CGFs.
   F. Support the DMSO High Level Architecture.

This project will support the following objectives: 1,2,3,4,5

**EXECUTABILITY**

This project will be executed by the TRADOC Analysis Center at Ft. Leavenworth, KS.

*AMIP-98-DEPL-01*

**PROJECT TITLE** **Development of an Extensible Hierarchy and Object Representation for Deployment Models and Simulations**

**STANDARDS CATEGORY** Deployment/Redeployment

**POINT OF CONTACT**

MTMCTEA
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## EXECUTIVE SUMMARY

There are several deployment tools available that model and simulate full spectrum deployment operations. Currently, unit, cargo, infrastructure, and asset data are entered into these models and simulations separately and in various formats. This results in many data inconsistencies and makes integration of and interoperability between models very difficult and time consuming. An common and extensible deployment/transportation object library and object hierarchy which contains very detailed attribute data for units, military cargo, infrastructure, and transportation assets would allow all deployment models to utilize the same (standard) set of underlying object data and would significantly reduce the effort spent to integrate models and to determine transportation system results. The development of a general-purpose extensible deployment object library, which will support all military models and simulation systems, is proposed. This library will be developed using the Java programming language, which will allow for a platform-independent solution that can serve all users throughout DOD. The products produced by this effort include a detailed object design specification document and Java source code extensible deployment object library.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. Deployment of military forces to worldwide destinations has become increasingly complex and costly. Because of this fact, the Military Traffic Management Command Transportation Engineering Agency (MTMCTEA) and others are developing models and simulation systems to analyze military deployments. These models are run prior to executing the deployments in order to ensure that efficient operations are conducted. The deployment models and simulation systems rely heavily on unit, military cargo, infrastructure, and transportation asset data that are needed to conduct analyses of the transportation system.

2. Currently, unit, cargo, infrastructure, and asset data are entered into simulation models separately and in various formats. This results in many data inconsistencies and makes integration of and interoperability between models very difficult and time consuming.

Many recent transportation and deployment model integration efforts, although beneficial to an extent, have been seriously flawed because they have lacked a common object representation that is essential for seamless integration and interoperation. This has resulted in severe deficiencies in realizing the full benefits that object technology and related modern software practices provide. An extensible deployment/transportation object library and object hierarchy which contains very detailed attribute data for units, military cargo, infrastructure, and transportation assets would allow all models to utilize the same set of underlying object data and would significantly reduce the effort spent to integrate models and to determine transportation system results.

## TECHNICAL APPROACH

1. The development of a general-purpose extensible deployment object library, which will support all military models and simulation systems containing detailed unit, equipment, and infrastructure, and transportation asset data, is proposed. This library will be developed using the Java programming language, which will allow for a platform-independent solution that can serve all users throughout DOD.

2. The purpose of defining and building an extensible object hierarchy is to support simulation systems through a comprehensive and standard_object representation that contains the necessary data in-core for the simulations. This system would be key middleware that would allow connectivity between deployment related_data, that is stored in back-end databases, with front-end simulation systems. The library/repository structure would be interfaced with any simulation using a communication protocol, for example the High Level Architecture (HLA). Java would provide the platform-independent solution to link to back-end databases (whether they be relational or object databases) using the JDBC (Java Database Connectivity) tool. Additional security benefits would be expected because of the inherent security features built into the Java language.

3. In order to develop this common deployment object library it will be necessary to:

   A. Define transportation and deployment objects
   B. Determine the logical organization of the object hierarchy
   C. Identify interactions between objects through the use of object messages
   D. Define specific object attributes that will support very detailed (item-by-item) analyses.

4. The transportation objects used at installations and seaports form a rich basis of objects included in the deployment process and will be the foundation for this initial development effort. Almost everything that deploys begins at an installation and moves on some type of transportation asset. Objects included in the scope of installations and ports include:

   A. Vehicles
   B. Cargo: pallets, containers

C. Infrastructure elements
D. Transportation assets
E. Force units

5. In addition to the objects, the relationships among the objects is key to understanding and modeling the behavior of those objects as they progress through the deployment process.

## PRODUCTS

There will be two products of this effort:

1. Detailed object design specification document
2. Java source code extensible deployment object library

## MILESTONES

There will be four project milestones:

1. Initial object design review. Completed – 2QTR FY98.
2. Final object design review. Completed – 4QTR FY98.

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3. Completion of the object hierarchy source code. 4QTR FY99.
4. Completion of system testing and final delivery of object repository. 4QTR FY00.

## RISK/BENEFIT ANALYSIS

Benefits of this approach would include:

1. An initial framework for collaborative planning and analysis with object-oriented systems.
2. Assurance of object attribute and object behavior consistency in all simulation applications that rely on the underlying object representation,
3. Portability across hardware and operating system platforms, and
4. Security features, which are inherent in the Java language.

## EXECUTABILITY

The primary developers for this capability will be MTMCTEA and Argonne National Lab. A development contract is already in place between MTMCTEA and ANL that can support this effort. The contract can be executed immediately after contract award.

*AMIP-98-FDB-01*

**PROJECT TITLE** **FDB Facilitation of Standards Development Process**

**STANDARDS CATEGORY** FDB

**POINT OF CONTACT**

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**EXECUTIVE SUMMARY**

1. This project will integrate multiple Standard Categories Coordinator's (SCC) projects and utilize the Functional Description of the Battlespace (FDB) as the means to execute the standards development process (SDP). The FDB can immediately support the electronic (via the internet) means to achieve consensus, promulgate standards, educate, establish teams and define standards. Additionally, the FDB can provide support in the requirements definition and validation process. This support is graphically depicted in Figure 1. The processes outlined in blue are the current FDB functions and demonstrate how the FDB can support the SDP process.

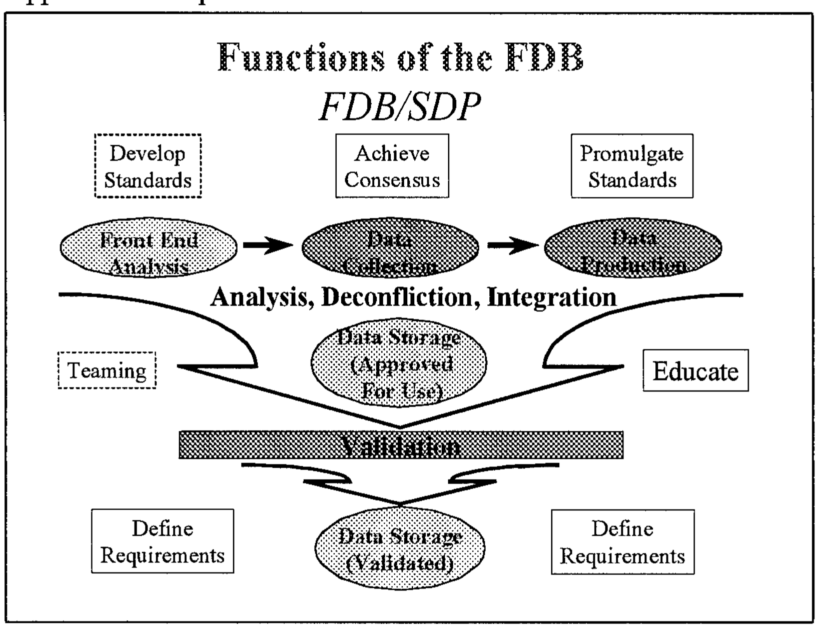


**Figure 1. Integration of SDP and FDB**

2. The FDB will provide a repository for data developed as well as complete traceability of all pertinent actions. This project has three distinct levels of execution

   A. **Level 1 Immediate Use of the FDB (In current configuration)**

B. **Level 2 Development of SCC "FDBs" (Non-Resident[1])**

C. **Level 3 Development of SCC "FDBs" (Resident)**

3. This proposal calls for the execution of levels 1 and 2 and an analysis of the additional cost to field level 3.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. The Army's M&S Master Plan extensively discusses the objective M&S environment. The central tenets of the objective environment are common use of applications and reuse of data. The current 19 standards categories represent centers of technological and procedural excellence. Their objectives are to develop and evolve Army M&S standards. In order to achieve these goals, the SCCs require an electronic repository for the data they produce as well as a means to execute the SDP. Currently, several different solutions are being applied by the SCCs. Some use local web sites while others are forced to execute the SDP in a manual fashion. In either case, there is no traceability of pertinent actions as data is validated.

2. The Functional Description of the Battlespace is a fully functional electronic data repository that is currently in use to support the development of WARSIM 2000. It is a system that produces, documents and archives accurate, validated and traceable standard descriptions of the components and characteristics of Army Battlespace functions. It is the linchpin that links the Field Army in the real world to the environment of a constructive simulation. This key role is demonstrated in figure 2.

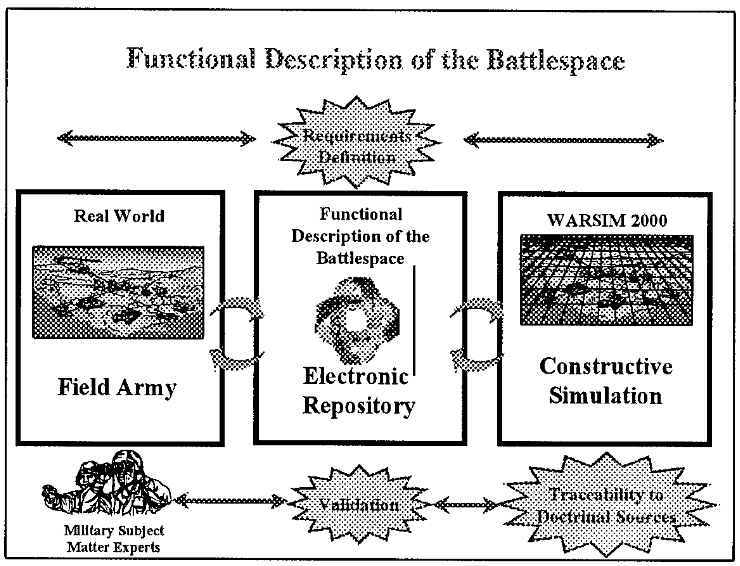


**Figure 2. FDB's Role in Simulation Development**

[1] The term "resident and non-resident" is in reference to the location of the data producer.

3. Widely known, updated and accessible software repositories provide a ready source of this information for users and developers and aid in spreading proven techniques and procedures throughout the M&S community. The FDB is such a repository. The FDB has the capability to accept data in hard or soft copy and provide the SCC cataloging service to include access, authorization and authentication, registration and release. In addition, the FDB offers the SCC a Forum by which users can provide comments on products and serve as the vehicle to validate information with the authorized data source. This process is currently being utilized to validate knowledge acquisition products developed for WARSIM 2000 by Lockheed Martin Information Services (LMIS). This same Forum provides the SCC with the means to manage the standards development process. The FDB provides a complete record of all transactions and as such provide the SCC with complete traceability throughout the life of the data. This project can provide various levels of support to the SCC depending on the specific needs of the coordinator and the resources provided. The three levels are:

4. **Level 1 Immediate Use of the FDB (In current configuration).** Level 1 provides the SCCs with an immediate electronic repository for their data. Data would be entered into the existing architecture of the FDB. Minor software changes would be required to allow the user to easily find the data. The SCC would also be provided with his own Special Interest Group (SIG) in the Forum which would allow him to manage the life cycle of his data. This level also allows the user to provide comments on the displayed data which is recorded and provided to the SIG/SCC. This allows the SCC to validate data in a distributed fashion.

5. **Level 2 Development of SCC "FDBs" (Non-Resident[2]).** At this level, the existing software would be modified to develop a "stand alone FDB" that belongs solely to the SCC. It would have all the functionality of the FDB with a look tailored to the individual SCC. At The software would reside on the current FDB server.

6. **Level 3 Development of SCC "FDBs" (Resident).** This level is essentially the same support as in level 2 with the exception that the software would reside on a server located with the SCC.

## TECHNICAL APPROACH

1. Level 1

   A. The Level 1 approach stores the SCC's data within the existing FDB's database and relies on the current FDB System Administration procedures.

[2] The term "resident and non-resident" is in reference to the location of the data producer.

B. The Level 1 approach requires little or no change to the FDB hardware and software. The SCC's data will be incorporated into the existing FDB databases. Management of the hardware and software as well as System Administration functions will be the responsibility of the current FDB maintainers.

C. Additional hardware and Internet connectivity may be required to support increased data storage and access requirements. System maintenance (including backups and software fixes/enhancements) will be handled along with the current FDB's maintenance.

D. Under the Level 1 approach, the SCC has a small role in system administration. New procedures must be developed for acquiring and updating the SCC's data. Figure 3 illustrates the level 1 approach.

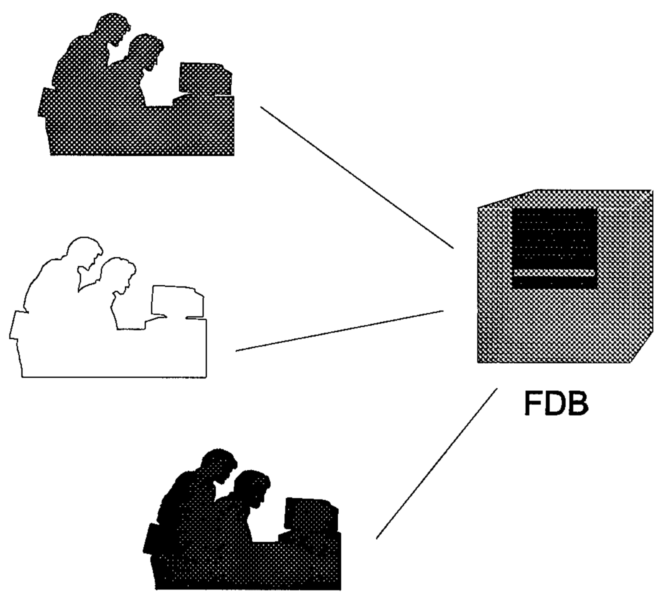


**Figure 3. Level 1 Technical Approach**

2. Level 2

A. The Level 2 approach creates a "virtual" FDB using the existing hardware, software, and databases. The SCC will have system administration privileges for the virtual FDB. Using a web-based interface to the virtual FDB, the SCC will handle system administration functions such as granting user access, adding information to the database, and creating Forum Special Interest Groups.

B. Although the data and software will reside on the same system as the current FDB, a separate web address (URL) will be used to access the SCC's version of the FDB. Users will see a system separate from the existing FDB.

C. The Level 2 approach requires enhancement of the FDB's System Administration functions. The functions will permit the FDB to present a "virtual" view of the FDB to the SCC and to user's accessing SCC's data through the FDB. The FDB software will be modified to recognize key fields or to use additional database tables to maintain separate views of the FDB. Some additional System administration functions will be added to permit remote maintenance of the system (including importation of data) by the SCC.

D. Additional hardware and Internet connectivity may be required to support increased data storage and access requirements. System maintenance (including backups and software fixes/enhancements) are handled along with the current FDB's maintenance.

E. Under the level 2 approach, the SCC maintains control over the SCC's data and access to the SCC's data. The SCC will be free of the responsibility for performing routine maintenance tasks (such as daily backups) and software fixes/enhancements. Figure 4 illustrates the level 2 approach. The "virtual" FDBs reside on the same server.

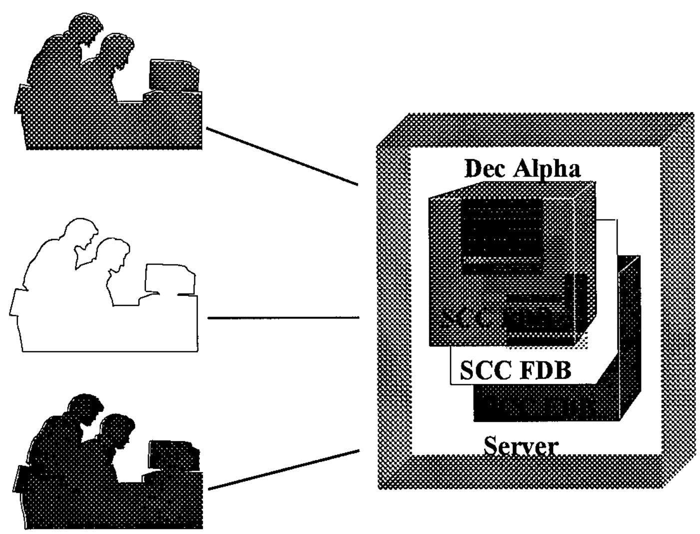


**Figure 4. Level 2 Technical Approach**

3. Level 3

A. The Level 3 approach duplicates the existing FDB hardware and software at the SCC's site. Therefore, little or no change will be necessary.

B. The Level 3 approach will require the purchase and installation by the SCC of a complete hardware suite, purchase of licenses for system software, purchase of maintenance agreements for the hardware and software, and the installation and monthly rental of an Internet connection.

C. Maintenance and enhancement of the FDB software will become more difficult since the software will be hosted on multiple systems. A procedure for ensuring that updates are replicated at all remote sites must be developed. Once the system is remotely hosted, the possibility exists that the development of the systems will diverge resulting in duplicated effort.

D. Each SCC hosting a remote FDB site will be required to perform daily backups and other routine maintenance tasks. Figure 5 illustrates the level 3 approach with software residing on separate servers.

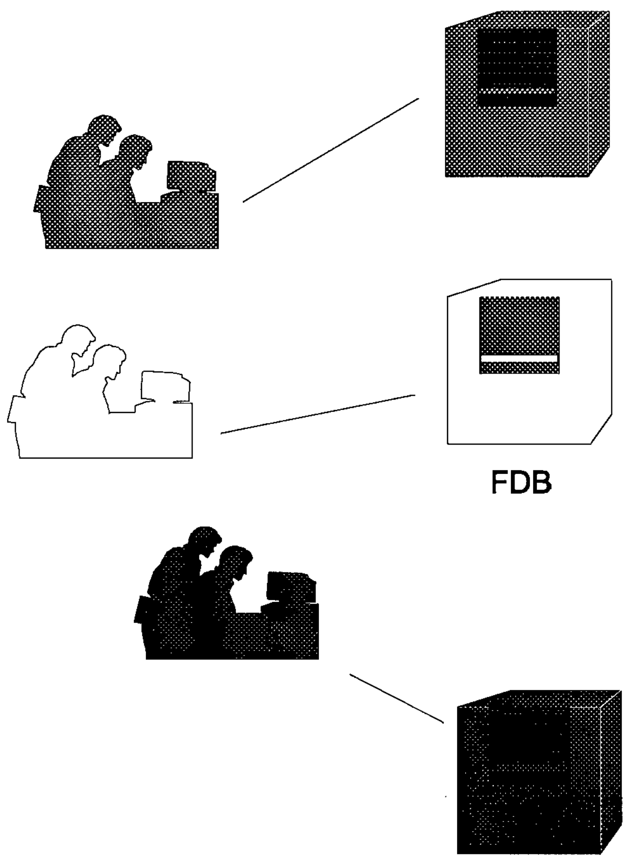


**Figure 5. Level 3 Technical Approach**

## PRODUCTS

- SCC/FDB Charter
- SCC/FDB Project Plan
- Four (4) Quarterly Reports
- "Modified" FDB (Level 1)
- "Stand Alone FDB" (Level 2)

- "Stand Alone FDB" (Level 3)

A SCC/FDB charter will be developed under the auspices of this project. The SCC/FDB charter will not only outline the support this specific project will provide to the SCCs, it will describe the roles and responsibilities of the FDB as a separate Standards Category. The project plan will be initiated immediately upon receipt of funds and will develop the detailed work schedule and timeline of deliverables. The plan will also provide for coordination with the other SCCs to determine individual needs as well as brief backs to gain consensus before software changes are implemented. Provided as a management tool for AMSO will be four quarterly reports which will fully describe the status of the project. Specific format of the quarterly reports will be detailed in the project plan. The common deliverable is the Functional Description of the Battlespace. Under Level 1, the SCC will be provided with the FDB to serve as a repository for their data as well as a Special Interest Group to manage their data and execute the SDP. At Level 2, the SCC will receive its' own version of the FDB. The engineering effort that established the FDB will be leveraged to develop a site solely for the use of the SCC. The software will remain resident on the FDB server. The Level 3 deliverable is the same software as provided in Level 2. The Level 3 effort, however, will have the software residing at the SCC's location. Each level represents state-of-the-art in collecting, verifying, validating and storing information and data that supports the Army's M & S objectives. This effort achieves the goals as outlined in AR 5-11 in that they:

- ***Provide a common set of verified, validated and certified data which can be shared by Army Modeling & Simulation activities.***

- ***Improve data quality and accuracy and minimize the cost of data production and data maintenance IAW DoDD 8320.1, DoD Data Administration and DoD 8320.1 M, Data Administration Procedures.***

**MILESTONES**

| Event | Date |
|---|---|
| Coordination w/ SCCs | TBD |
| Project Initiated | 1 Oct 97 |
| Initiate Level 3 Analysis | 01 Oct 97 |
| SCC/FDB Charter | 31 Oct 97 |
| SCC/FDB Project Plan | 31 Oct 97 |
| "Modified" FDB (Level 1) Complete | 31 Oct 97 |
| Back Brief to SCCs | TBD |
| Level 3 Analysis Complete | 12 Nov 97 |
| "Stand Alone FDB" (Level 2) Complete | 03 Dec 97 |
| Quarterly Report (1ST Quarter 98) | 05 Jan 98 |
| Quarterly Report (2ND Quarter 98) | 06 Apr 98 |
| Quarterly Report (3RD Quarter 98) | 06 Jul 98 |
| Quarterly Report (4TH Quarter 98) | 05 Oct 98 |
| "Stand Alone FDB" (Level 3) | TBD |

## RISK/BENEFIT ANALYSIS

1. The FDB Integrated Product Team can propose an extremely cost effective solution based on three years of dedicated development that has already gone in to this fully fielded system. The customer is only required to provide the resources to modify this successful program. Level 1, 2 and an analysis of Level 3 can be accomplished. The costs to field Level 3 cannot be determined until an analysis of the requirements is completed of the various SCC sites.

2. Overall, Level 1 and Level 2 builds have an extremely low probability of failure. The FDB is currently up and operating on the world-wide web. Modification of the current version will be performed by the same engineers who developed the FDB. This experience will ensure a smooth transition. A level 3 analysis of the various sites is required to determine the capability of the SCCs to maintain an independent site.

## EXECUTABILITY

The FDB Material Developer (STRICOM) and System Manager (TRADOC) will provide oversight and guidance. Veda, Inc, the FDB contractor, will provide project execution and management.

*AMIP-98-SAF-01*

**PROJECT TITLE** **Implementation of a Standard Behavioral Representation for ModSAF, OneSAF and CCTT SAF**

**STANDARDS CATEGORY** Semi- Automated Forces

**POINT OF CONTACT**
TRADOC Analysis Center
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**EXECUTIVE SUMMARY**

1. In order to successfully use a task training simulation, behaviors should accurately represent BLUFOR and OPFOR units. It is not sufficient to use the same collective tasks for the OPFOR as those used for the BLUFOR. Because OPFOR units are provide an intelligent adversary for training BLUFOR units, it is necessary to implement validated, standard OPFOR behaviors in Army SAFs. The US Army and the Russian-Heavy force that the OPFOR is being modeled after do not perform in the same manner in all cases. The CATT program has developed validated OPFOR Combat Instruction Sets (CISs) for use in the CCTT SAF program. Currently, ModSAF shares code for BLUFOR and OPFOR units. The OneSAF program, which is the follow-on program for CCTT SAF, ModSAF, and Janus, is planning to use government furnished behavioral standards within the OneSAF model.

2. OPFOR CISs developed for CCTT SAF are traceable to tactical and operational writings produced by the US Army TRADOC Combined Arms Center's (CAC) Threat Support Division. The definition of a CIS is shown below.

   **CIS** - Descriptions of the vehicle/unit behaviors of the BLUFOR and OPFOR units which make up the Semi-Automated Forces of CCTT and other CATT simulators.

3. TRAC requests funds to evaluate, and implement 20 key OPFOR CISs in ModSAF, prepare the associated code and documentation, verify and validate the code, and prepare a software change package for inclusion in the next ModSAF baseline release. TRAC will also provide this code, conceptual models, and documentation to the OneSAF M&S program. **The result will be an OPFOR behavioral standard that will be implemented in the three major Army SAF programs- CCTT SAF, ModSAF, and OneSAF.**

**BACKGROUND**

Preliminary research has shown OPFOR CIS implementation in ModSAF can result in a marked improvement in individual behavior. A comparison of those tasks with the same tasks as they were originally implemented in ModSAF has shown that the ModSAF behaviors can be implemented correctly using the CCTT SAF OPFOR CISs, resulting in a validation of that behavior. This project would implement key OPFOR CISs in ModSAF, which would result in the existence of entity tasks and behaviors that are traceable to validated Soviet/Russian data. These key CISs, selected because they serve as the basis for many other behaviors, are shown in section IV.

The implementations involve work at the source code level in both CCTT and in ModSAF. The CCTT source code for the behavior is thoroughly examined and outlined so the same implementation can be coded into ModSAF.

## TECHNICAL APPROACH

Preliminary research involving CIS implementations in ModSAF has shown that the project is technically feasible.

The technical approach for the project is as follows:

1. Select a candidate OPFOR CIS.
   a. Confirm its implementation in CCTT SAF.
   b. Check for the existence of a similar task in ModSAF. If the code exists, then compare the ModSAF code with the code for the CCTT SAF implementation in an effort to avoid re-creating code. If the code does not exist, then it must be created.
2. Determine the doctrinally correct execution of the task or behavior.
   a. Prepare a flow diagram of the OPFOR CIS.
   b. Prepare a list of the OPFOR CISs that are dependent upon the CIS being implemented.
   c. Determine terminating conditions: what constitutes when the task begins, when it is executing and when the task terminates.
3. Examine the CCTT SAF implementation of the code.
   a. Outline a state diagram of the functions, how they execute and the order in which the transitions or function calls occur as they are implemented in CCTT SAF.
   b. Use step 2a to create a high level picture of the CCTT SAF code.
4. Review ModSAF for existing code to either be used as a basis for the new CIS or provide supporting functionality for the new CIS.
   a. Create a high level diagram that explains general actions occurring in each state.
   b. Document any ModSAF supporting tasks which will assist in implementing the CIS.
5. Create an Acceptance Test Plan. Outline the requirements that the task must meet before a design is created.
6. Verify that the task are implemented in a doctrinally valid manner.
7. Implement the behavior or task in ModSAF.
   a. Write and debug the source code.
   b. Review the code for correctness and efficiency.
   c. Document the code using the ModSAF Style Guide, as defined by the ModSAF Configuration Control Board (CCB).

   d. Verify and validate the resulting code

8. Design and create a scenario which will sufficiently test the newly implemented behavior.
9. Validate the behavior, using an SME, in the context of the scenario.
10. Document the resulting code and V&V data.
11. Prepare a submittal package, including the necessary V&V reports, for consideration for inclusion in the ModSAF baseline.
12. Provide a submittal package to OneSAF M&S proponents.

**PRODUCTS**

1. Source and executable ModSAF version 4.0 with doctrinally correct tasks and behaviors for the following OPFOR CISs:

Hvy-0001, Execute Column Formation
Hvy-0002, Execute Line Formation
Hvy-0003, Execute Wedge Formation
Hvy-0006, Occupy an Assemble Area
Hvy-0010, Execute a Fire Engagement
Hvy-0012, Occupy a Strong Point
Hvy-0013, Actions When Under Incoming Indirect Fire
Hvy-0014, Conduct Tactical Road March
Hvy-0015, Conduct a Defense
Hvy-0022, Assault an Enemy Position
Hvy-0023, Take Air Defense Measures
Hvy-0027, Occupy Temporary Defensive Position
Hvy-0028, Traveling
Hvy-0029, Take Evasive Actions
Hvy-0030, Withdraw/Disengagement
Hvy-0101, Column Formation
Hvy-0102, Line Formation
Hvy-0103, Execute Wedge Formation
Hvy-0108, Traveling
Hvy-0117, Occupy a Temporary Defensive Position.

2. Documentation describing traceability of OPFOR CIS to ModSAF behavior for V&V report
3. Documentation describing verification of new code
4. V&V reports and data
5. Submittal package for inclusion into ModSAF baseline

**MILESTONES**

| Document CIS | Document ModSAF | Implement in ModSAF | Test the Results Verify and validate code | Document Results Prepare V&V report |
|---|---|---|---|---|
| 8 hours | 8 hours | 32 hours | 40 hours | 16 hours |

**Figure 2. Tasks per typical CIS**

1. The entire process, with one person implementing one CIS in ModSAF, averages 104 hours for the typical OPFOR CIS. The amount of time required will also be reduced as experience allows personnel to become more familiar with the CCTT SAF architecture

and the implementation process.

2. Work will be completed one year after receipt of AMIP funds.
3. Physical observation of the CCTT SAF behaviors is not possible as CCTT runs on an IBM RISC-6000 system, and this system is not available at TRAC. Therefore, the source code will be used to investigate the CCTT SAF behaviors.

**RISK/BENEFIT ANALYSIS**

These implementations would provide the following benefits to the Army:

1. Behaviors traceable to doctrine is essential to establishing validity in ModSAF and OneSAF.
2. The behaviors and interaction between simulator and user would be more realistic.
3. ModSAF and OneSAF would be credible representations of OPFOR units.
4. Provide basis for OneSAF OPFOR behavioral development.

**SUPPORT TO STANDARDIZATION OBJECTIVES**

Standardization objectives for CGF are outlined in the 1998 CGF report. These are shown below.

1. Develop valid behavioral, data, and physical model standards for use in OneSAF.
2. Develop CGF standards that are useful in all M&S domains, applicable to distributed simulations, representative from single entity to corps, and useful in a joint environment.
3. Minimize operator overhead for CGF.
4. Ensure structures and data bases are modular and easily isolated.
5. Provide consistent representations for battle field systems, and unit tactical/doctrinal behaviors in all CGFs.
6. Support the DMSO High Level Architecture.

This project will support the following objectives: 1,2,4,5

**EXECUTABILITY**

The project will be executed by the TRADOC Analysis Center at Ft. Leavenworth, KS.

*AMIP-98-OMSC-01*

**PROJECT TITLE** **Standard Object Development**

**STANDARDS CATEGORY** Object Management

**POINT OF CONTACT**

U.S. Army Materiel Systems Analysis Activity
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## EXECUTIVE SUMMARY

This proposal is directed at accomplishing two objectives. The first is to develop an initial set of standard objects for use in Army models and simulation. The second is to develop a set of tools and procedures that will provide for the development, control, dissemination, and updating of standard Army objects.

## BACKGROUND

Object-oriented programming offers the potential for increased code reuse, maintainability, and ease of developing entity-level simulations. Because of these benefits, the use of object-oriented technologies will increase over time. In order to prevent duplication of effort and the development of incompatible models, objects will need to be managed. To address this issue, the Deputy Undersecretary of the Army for Operations Research (DUSA-OR) directed the development of an Army object management policy. This proposal encompasses the tasks necessary to develop this policy and lays the foundation for the development of Army standard objects.

## TECHNICAL APPROACH

Based on the initial guidance to the Object Management Standards Category (OMSC), this project is focused on the development of abstract object class definitions. This effort will develop functional definitions of objects that are robust and reusable by different simulation development applications versus developing specific objects in a specific language for a specific application. The approach selected for this project resembles the model-test-model methodology used by the modeling and simulation community. Specifically, this project will first develop an initial set of objects proposed for M&S community use. The project will then develop a set of object management tools and procedures for object storage and retrieval. Next, an additional set of new objects will be developed using these new tools and procedures expanding the initial set of objects. Based on this process, the object tools and procedures will be refined with the final results to be presented to the Army modeling and simulation community for review. The six major phases and/or components of this project are as follows:

1. **Develop Initial Set of Abstract Objects**

This phase will start with an initial set of objects developed by TRAC-MTRY. Their effort was designed to identify an initial set of entities, entity attributes, and entity interactions through the review of key Army combat models. The focus of this phase will be to associate standard data/sources of data with attributes and associate standard algorithms/sources of algorithms with methods. During this process, missing standard data or algorithms will be identified and reported to the appropriate standards category. This first set of objects will be provided to a wide spectrum of the Army modeling and simulation community for review and comment.

2. **Develop Abstract Object Taxonomy**

An object taxonomy will be developed concurrently with the first phase. The intent of this effort will be to provide a structure that will allow for the categorization of objects. Characteristics in this taxonomy will include:

- granularity or resolution (i.e., aggregate units, individual platforms, system/subsystem, and components)
- domain (i.e., TEMO, ARC, and RDA)
- function (i.e., force development, training, test, engineering, etc.)
- timing (i.e., real time and non real time).

With this taxonomy, it will be possible to identify duplication of effort as well as identify potential voids in the available set of Army objects.

3. **Develop Object Documentation Format**

This phase will focus on the development of a standard to document objects. Included in this effort will be a determination documentation content, documentation format, object communication protocols, attribute data formats, meta-data requirements. Development of an object documentation format will allow objects developed by different organizations to be shared across the Army/DOD modeling and simulation community.

4. **Develop Additional Abstract Objects**

After the development of a prototype object documentation format, additional objects in new areas will be developed. These new objects will be used to test and enhance, as required, the object documentation format.

5. **Prototype Automated Tools**

This phase is directed at proto-typing a set of automated tools to assist in the documentation and use of Army objects. The primary figures of merit for this effort are ease of use and the ability to distribute the tool set to interested organizations.

6. **Develop Object Nomination and Control Policy/Procedures**

The final phase of this project will develop recommended policies and procedures for object development, distribution, ownership, control, and maintenance.

**PRODUCTS**

1. Initial set of standard objects for combat simulation
2. Object management procedures
3. Object management tools
4. Identification of standard data/algorithm voids for object development
5. Object taxonomy with assessment of coverage and voids

**MILESTONES**

| | O | N | D | J | F | M | A | M | J | J | A | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Develop Initial Set of Objects | | | | | | | | | | | | |
| Develop Taxonomy | | | | | | | | | | | | |
| Develop Object Format | | | | | | | | | | | | |
| Develop New Objects | | | | | | | | | | | | |
| Develop Tools | | | | | | | | | | | | |
| Develop N/C Procedures | | | | | | | | | | | | |
| Document Results | | | | | | | | | | | | |

**RISK/BENEFIT ANALYSIS**

The risk to complete this effort is assessed to be low. A number of potential solutions to the problems addressed by this project have been proposed or exists. The major challenge is to select/develop a set of solutions that are tailored to the needs of the Army modeling and simulation community. The ultimate benefits to be derived from the availability of standard Army objects include:

- Reduced knowledge engineering development efforts for new models
- Enhanced interoperability/interactivity
- Reduction in duplication of effort, and
- Identification of investment opportunities to address modeling and simulation voids

**EXECUTABILITY**

The funding requested for this project will be used for in house government labor at AMSAA, TRAC-WSMR, TRAC-FLVN, TRAC-MTRY, and CAA.

*AMIP-98-MOB-02*

**PROJECT TITLE** **Standard Sourcing Tool for Generation of Forces**

**STANDARDS CATEGORY** Mobilization

**POINTS OF CONTACT**

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**EXECUTIVE SUMMARY**

There is significant interest in providing commanders and other decision-makers with the necessary tools to assist in developing and analyzing mobilization and deployment courses of action (COA) rapidly. Analysis of COAs must be based on TPFDDs (Time Phased Force Deployment Data) that are sourced with actual available units that can best meet the supporting commander's requirements. There is more than enough data available in command and control databases, but its retrieval, manipulation and formatting as information takes too long manually or with existing, older generation automated tools. We must provide action officers/analysts with a tool that is available on the Army Global Command and Control System (AGCCS), that utilizes standard methods of analyzing sourcing options and force generation to enhance the current mobilization process.

**BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM**

1. Currently, there are two models in the Modeling and Simulation Community which perform similar force generation and sourcing analysis, SABRE (Single Army Battlefield Requirements Evaluator) and MARTYR (Matching Army Requirements to Yearly Resources).

2. SABRE was developed by the U.S. Army Artificial Intelligence Center to help identify actual units to meet mission requirements. It requires an input of a JOPES TPFDD or a listing of SRC requirements generated by another means, such as FASTALS (Force Analysis Simulation of Theater Administrative and Logistics Support) or FAST-OR (Force Analysis Spreadsheet Tool-Operations Other than War Requirements). SABRE uses SORTS and Army SAMAS data to source or review sourcing of a TPFDD. By

using a set of filters, SABRE checks existing sourced units for fit, identifies shortfalls and candidates to fill shortfalls. These user-defined filters consider location, status, providing organization, component, closeness of match to SRC requirements, and modernization level when recommending units for fill. SABRE can also use other TPFDDs or force packages as either sourcing pools or exclusion pools when sourcing a TPFDD. If the starting point is a simple list of requirements, SABRE will generate ULN (Unit Line Number) structure for migration through DART (Dynamic Analyzer and Resource Tool) into a full JOPES TPFDD format.

3. MARTYR was developed by the U.S. Army Concepts Analysis Agency to help assess shortages in force structure while attempting to meet mission requirements. It can accept requirements in the form of a SRC listing, TPFDD, FASTALS troop list, or Mission Task Organized Force. MARTYR has the ability to place numerous TPFDDs on a common time line and sources units chronologically. It also identifies where and when units are slotted to go to more than one theater. MARTYR uses SAMAS to establish a pool of available units and extracts of SORTS, TOE, and TORGNA data in its sourcing process. It uses several weighting criteria in selecting units to meet requirements and any field in SAMAS can be used as selection criteria. MARTYR creates reports and tab delimited output files for easy loading in to EXCEL spreadsheet.

4. Both these models are written in Lisp programming language and need to be converted to a programming language compatible with AGCCS. To conserve resources and delete duplication of effort, this project will combine functionality of these two models to ensure functional requirements are met for both the operational planner and program analyst. Additionally, this project will analyze the standard data needed to support this project and analyzing the use of Actual Unit Equipment Listing (AUEL) and Type Unit Characteristics (TUCHA) data.

## TECHNICAL APPROACH

1. This effort to provide a standard sourcing decision support tool for generating forces will review the strengths and weaknesses of existing models. A review of functional requirements will also be conducted with the current users.

2. Use Artificial Intelligence technologies in rule-driven scoring strategies and domain specific heuristics to solve constraint satisfaction problems related to sourcing (identifying) unique military units to meet specified mission requirements. Incorporate the latest click-and-drag technology in building hierachial command structure of mission requirements/operational plan.

3. Conduct assessment of emerging information technology interfaces with AGCCS, which will enable users to access standard sourcing decision support tools quickly and easily from their native operating system.

## PRODUCTS

This effort will provide standard sourcing decision support tools, that can be accessed through the Army Global Command and Control System (AGCCS), to support current military planning needs at the U.S. Army Concepts Analysis Center, Forces Command, and U.S. Army Europe and future planners, analysts and decision-makers throughout the Army and Joint Staff.

## MILESTONES

| Events | 1997 Period | | | |
|---|---|---|---|---|
| | 1st QTR | 2nd QTR | 3rd QTR | 4th QTR |
| Review functional requirements | x | | | |
| Review emerging technologies | x | | | |
| Plan programming efforts | x | x | | |
| Conduct programming efforts | | x | x | x |

## RISK/BENEFIT ANALYSIS

Although this project will explore the latest information technology interfaces, the risk involved is relatively low. The current SABRE prototype has matured over the years and needs to be accessed through AGCCS in order for the action officer/analyst to utilize it to its full potential. This effort will standardize methods of analyzing sourcing options and force generation to enhance the current mobilization process.

## EXECUTABILITY

This work will be completed by AI Center on-site contractor personnel under existing contract vehicle.

*AMIP-98-MOVE-01*

**PROJECT TITLE** **Standards for Engineer Mobility and Countermobility Operations in Modeling and Simulation**

**STANDARDS CATEGORY** Move

**POINTS OF CONTACT**

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## EXECUTIVE SUMMARY

Directions provided by senior Army leaders have emphasized the importance of providing standards, in a timely manner, to support the next generation of Army models and simulations, in particular WARSIM 2000, and the Army's contribution to JWARS and JSIM. The purpose of this study is to provide standards for Army engineer mobility and countermobility operations in a theater of operation. The standards developed will support the training simulations and have application in future command and control systems. The development of a first generation engineer command and control software suite (E-OPS) is near completion and is undergoing field test exercise evaluation at multiple echelons of command. This software suite and supporting documentation will serve as a baseline for the formulation of standards. Other contribution sources of information are the Engineer Functional Area Model (E-FAM), legacy systems such as CASTFOREM, VIC and EAGLE and current doctrinal publication. This broad base of technical information will provide the basis for standard algorithms or tactics, techniques and procedures for engineer mobility and countermobility representation on M&S.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. The Army initiated the standards process for modeling and simulation in 1995 to provide a consistent basis for representation of battlefield functions in the hierarchy of models and simulations. To accomplish this, standards categories were identified and expert technical representatives from across the army were assigned to each category to pursue the development of standards that can be used to support development of future modeling and simulation and possibly enhance existing modeling and simulation.

2. In FY95 the Battlefield Algorithms Move standards category team evaluated movement representation in nine constructive models. In FY96, a review of movement representation in nine virtual systems was undertaken. Recognizing that engineer mobility and countermobility operations are force multipliers on the battlefield, additional emphasis needs to be placed on developing standards for each since significant work has been accomplished in the development of the prototype engineer command and control system,

E-OPS, for which the Engineer School is the proponent. E-OPS contains doctrinal representation for mobility and countermobility operations and is currently undergoing hands-on user evaluation at multiple echelons of command during CPX/FTXs. The Engineer Functional Area Model (EFAM), which was completed a few years ago, will serve as an additional source of mobility and countermobility representation. Further efforts to improve the representation for these two mission areas in existing modeling and simulation will support development of standards.

## TECHNICAL APPROACH

The technical approach to be used in defining the standards for engineer mobility and countermobility operations is as follows:

1. Using current doctrinal publication, Field Manuals, student texts, etc., determine the doctrinal standard for engineer mobility and countermobility operations.

2. Compare the representation within E-OPS against the doctrinal standard, item 1a, and document.

3. Compare the representation within E-FAM against the doctrinal standard, item 1a, and document.

4. Compare the representation within current M&S systems (i.e. JANUS, CASTFOREM, VIC, EAGLE, MODSAF, and CCTT) against the doctrinal standard, item 1a, and document.

5. From items 1a - 1d, provide recommendation for standard representation in M&S for engineer mobility and countermobility representation.

A technical report will be published to document the results of the investigation for standard representation of engineer mobility and countermobility operations in M&S.

## PRODUCTS

A technical report will be published detailing the investigation of the representation of engineer mobility and countermobility operations in M&S. Doctrinal standards will be identified and representation of these standards in developed programs such as E-OPS, EFAM and legacy M&S systems will be evaluated. From this documentation and analysis, standards for mobility and countermobility representation in M&S will be recommended.

## MILESTONES

| Events | FY98 Period | | | |
|---|---|---|---|---|
| | 1Q | 2Q | 3Q | 4Q |
| Identify doctrinal responsibilities for mobility and countermobility | | | | |
| Determine representation in E-OPS | | | | |
| Determine representation in EFAM | | | | |
| Determine representation in legacy M&S system | | | | |
| Final editing and publication of Mobility/ Countermobility standards | | | | |

## RISK/BENEFIT ANALYSIS

There is significant interest in establishing standards for Army M&S as a means to reduce the cost of development of M&S for the domains that support the Army. The standards developed for mobility and countermobility will support M&S across echelons of command and control. A first generation prototype for engineer C2, E-OPS, has been developed and can serve as a baseline for evaluation of mobility and countermobility operations. Other legacy code, EFAM, JANUS, CASTFOREM, VIC, EAGLE, ModSAF, and CCTT will support development of standards. This effort will be completed at the end of FY98 and be supportive of the development of WARSIM 2000, JWARS and JSIM. Risk is considered low; benefits high.

## EXECUTABILITY

*AMIP-98-TERR-01*

**PROJECT TITLE** **The Effect of Feature Data on Line-of-Sight (LOS)**

**STANDARDS CATEGORY** Terrain

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**EXECUTIVE SUMMARY**

Prediction of realistic Line-of-Sight (LOS) conditions has always been an essential aspect of combat simulations. Several studies have been conducted over the years in order to better understand the technical issues associated with LOS prediction for Army applications. However, most of these studies have examined a "bald-earth" scenario using solely elevation data to represent the earth's surface. The representation of LOS in areas with surface features (vegetation) has never been extensively examined. However, recent advances in weapons systems, combat simulators, and the evolving mission requirements of the modern Army have demonstrated the need for a more precise understanding of how vegetation impacts LOS prediction. TEC and TRAC-WSMR recognize this problem and have developed a study to: (1) identify geotypical feature density zones; (2) document typical LOS within each with a field collection effort; and (3) predict future LOS performance. After completion of the field work, TEC and TRAC-WSMR will conduct an analysis of the field information and provide findings and recommendations to the Army community in the form of a final report. The study will: (1) facilitate the selection of a standard algorithm for LOS which performs effectively in varied feature densities and (2) provide recommendations on how to improve the play of surface features in combat models.

**BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM**

1. Prediction of LOS conditions has always been an essential aspect of the battlefield. Several studies have been conducted over the years in order to better understand the technical issues associated with LOS prediction for Army applications. Since the predominant focus of combat modeling has historically involved large armored simulations

(tank on tank), most LOS studies have assumed a "bald-earth" scenario using solely elevation data to represent the earth's surface. However, recent advances in weapons systems, combat simulators, and the evolving mission requirements of the modern Army (operations other than war, hostage rescue operations, peace keeping, and low intensity conflict) have demonstrated the need for a more precise understanding of the cultural and natural feature impacts of the terrain on LOS prediction. As recently as June 1997, the Institute for Defense Analysis recommended that research be conducted to explore the effects of LOS in vegetated areas.

2. One of the aspects of all of these new operations is how to represent LOS in a vegetated area in combat models. Currently, LOS in a vegetated areas is played in one of the following ways:

   A. The surface feature is treated as a complete blockage to LOS. This can be visualized by thinking of vegetation as a thick, black cloud with zero visibility.

   B. LOS within surface features is calculated in the same manner as above with one exception. The user inputs a distance that sensors can see into the surface feature. This allows units to deploy just inside the tree-lines while maintaining LOS to the battlefield. However, there is no quantitative basis for this "see-through" distance.

   C. Some models use a probability of LOS for every unit of distance (usually 25 meters) into an area with surface features. For example, if the user input is 0.9 and a sensor is trying to see 75 meters into trees, the probability of LOS is 0.729 (0.9 * 0.9 * 0.9). A random number is drawn in order to determine LOS. However, the probability input has no quantitative basis.

   D. A virtual simulator draws all the features between the sensor and the target one at a time in order to properly play their effects. This can be a time consuming process. The individual trees are stylized (they are all the same tree) and the number of trees located is a small area is limited by the polygon limits of the simulator.

3. Based on the above examples, there is no quantitative data to support any combat models for high resolution combat. A set of quantitative LOS data in areas of high feature density areas would help modelers portray combat in a more realistic manner. The M&S communities at TRAC-WSMR and TEC recognize this opportunity and have developed a field study to: (1) identify geotypical feature density zones; (2) document typical LOS within each and; (3) predict future LOS performance.

## TECHNICAL APPROACH

This study will be conducted by a TEC/TRAC-WSMR team that has extensive experience in "bald earth" LOS scenarios. Much the same methodology successfully used in these previous studies has been adapted to support this feature LOS work. Development of study area selection criteria will be the only new process, thus mitigating a substantial amount of risk. The technical approach is as follows:

1. Develop criteria for the delineation of geotypical feature densities using current Army requirements. This step will also examine the distribution of different climate/terrain areas based on a prior TEC study on geotypical terrain.

2. Characterize areas that TEC/TRAC-WSMR may have access to and/or where previous LOS information is available for comparison. Develop specific definitions of these areas so that they may be related to other geographic locations. Successful completion of this step will facilitate Army use by ensuring extensibility in widely varied locations. Areas should include but are not limited to CONUS military facilities. These initial locations will become the study areas where field work will be conducted. These locations will be selected to meet the following three criteria. First, areas will be selected to emulate foreign, denied, or cost prohibitive areas that are of current interest (for example, Korea, Bosnia). Second, areas which provide a variety of vegetation densities, undergrowth, and canopy conditions will be selected. Third, areas should have available Digital Feature Analysis Data (DFAD).

3. Once the study areas are identified, the origin points for collection of field LOS conditions will be selected based on correct Army tactical operations and where LOS will be blocked only by features data. Data will be collected within a tactical field of view in order to provide random observations.

4. Specific LOS information will be collected at each origin point. These measurements include:

   - Percentage of a soldier sized target visible for different ranges.
   - Percent canopy closure for several directions.
   - A description of tree types and a description of the undergrowth.
   - Whether or not an armored vehicle could operate in the area in conjunction with dismounted infantry.

5. Additionally, vegetation data collected for other studies (studies not associated with LOS) along with algorithms developed by Shelemyahu Zacks (Stochastic Visibility in Random Fields) will be enhanced with actual predictions. This will enable Professor Zacks' work to be implemented into combat simulation.

## PRODUCTS

After completion of the field work, TEC & TRAC-WSMR will conduct an analysis of the field information and provide findings and recommendations to the Army community in the form of a final report. A major section of the report will include a set of photographs depicting location, feature types, feature density, and distribution of LOS in each area. Expert military analysts will be able to examine these photographs and determine which of the surveyed areas best represent their areas of interest (i.e. Germany, Korea, Bosnia, Panama).

### MILESTONES

| Event | FY98 Period |
|---|---|
| The Effect of Feature Data on LOS | |

| | |
|---|---|
| • Field work preparation and collection | ▲ |
| • Analysis | ▲ |
| • Report preparation and publication | ▲ |

**RISK/BENEFIT ANALYSIS**

1. Acceptable methods for simulating LOS in vegetated areas is a relatively new concern for the Army. This is especially true for dismounted infantry simulation. Dismounted soldiers make every possible effort to maneuver and fight using some type of surface feature for cover. Therefore, the simulation of combat where there is a high density of surface features is a priority. This study will facilitate the selection of a standard algorithm for LOS which performs effectively in varied feature densities. It will also provide a geotypicial data library that will be available to developers of combat simulations.

2. Currently, five groups have expressed an interest in the results of this project or have a requirement for the results. These activities are listed below:

   A. The Rapid Force Projection Incentives (RFPI). The LOS study will be used as input to a multi-year study which begins next year. During the first year, the RFPI study will examine the effects on the terrain around Ft Benning, GA. In later years, this study will be expanded to areas in Korea, Bosnia, and Central America.

   B. Object Individual Combat Weapon System (OICW). The OICW is examining the effects of different weapon systems used by dismounted infantry. The weapon system that is rated highest will probably replace the M-16 rifle.

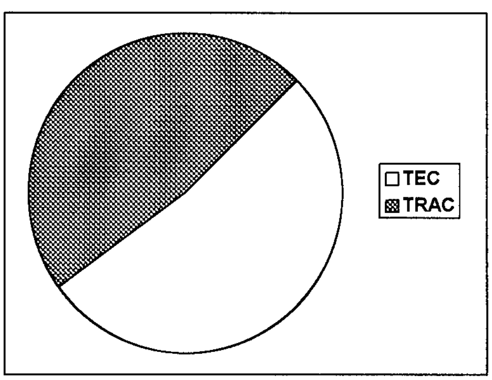
   C. Soldier Station. This is a DIS environment simulator that will replicate the effects of terrain/vegetation on a dismounted infantry soldier. Realistic representation of the battlefield is a vital concern.

   D. The Directorate of Land Operational Research in Ottawa, Canada.

   E. The Land, Space and Optoelectronics Division, Defence Science and Technology Organisation in Salisbury Australia.

**EXECUTABILITY**

All work will be conducted in-house by TEC and TRAC-WSMR.



*AMIP-98-DYNE-01*

**PROJECT TITLE** **The Modeling of the Ground State in Winter Environments**

**STANDARDS CATEGORY** Dynamic Environments

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## EXECUTIVE SUMMARY

Cold environments can have drastic effects on Army operations. Both existing and potential Army mission regions such as Korea, Mountainous Europe (Bosnia, Macedonia) and Northern Europe experience significant impacts from cold environments on Army operations. Currently available Army models and simulations have almost no ability to replicate these effects. During the winters of 95/96 and 96/97 a snow melt model was used in conjunction with a hydrological model to predict the level of the Sava river. At times both the magnitude and the timing of the river stage, as forecast by the models, were in error. When the data were reanalyzed it was found that the snow melt model was sensitive to the cloud component of the downwelling infrared flux, a parameter that is not available from standard meteorological observations and therefore must be calculated. A recent report published by the United States Military Academy (TR FY97/1 The effects of Cold Weather on Tactical Operations, West, et al) has shown that even a shallow snow cover of 7 inches increased friendly vehicle losses by over 70% in a JANUS experiment modified to show the impact of snow on mobility. An inaccurate forecast, or no forecast at all, of the impact of cold environments on Army operations can have a negative effect on training, result in inaccurate planning and faulty analysis and/or lead to subsequent failure of Army operations. This proposal will address the issue of predicting the state of the ground (snow cover, snow melt, and freeze/thaw depths) by utilizing CRREL's SNTHERM energy balance model. The proposal will investigate the sensitivity of the ground state to different flux initialization techniques, including initialization using a semi-empirical model, a plane parallel model, and ARL's AIM (Atmospheric Illumination Module).

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. CRREL has numerous winter data sets that can be used to initialize both SNTHERM and AIM. One of the more comprehensive data sets was collected during the winter at Grayling, MI under the JT&E SWOE program. These data sets also contain the information that can be used as ground truth. for the evaluation of the predicted solar and IR fluxes and ground state. Scenarios will also be run for data sets from Yuma and Grayling during the fall to investigate the sensitivity of the surface temperature to flux initialization for non-winter environments.

2. SNTHERM is a physics based model that can be used to determine the state of the ground including the surface temperature, the snow depth on the ground, snow water equivalent, the snow melt, and the snow physical characteristics. SNTHERM considers the exchange of energy via conduction, convection, radiation, and the mass flux of precipitation. SNTHERM is being used extensively in both the DoD scientific community and in the academic community.

3. The solar and IR fluxes can be calculated using the semi-empirical scheme of Shapiro and Wachtmann, a plane parallel scheme using MODTRAN, or AIM. AIM uses the Cloud Scene Simulation Model (CSSM) in conjunction with the Boundary Layer Illumination and Transmission Simulation (BLITS) radiative transfer program to determine the spectral and spatial distribution of fluxes in cloudy and clear atmospheres. CSSM is a stochastic cloud model that uses readily available cloud information to produce a 3 dimensional spatial distribution of clouds, including the distribution Liquid Water Content (LWC) within the clouds. The LWC information is used with cloud type and geometry data to determine scattering properties. This information is used in the calculations of the radiative fluxes. Unlike approaches presently in use that either use a parameterization scheme or require the use of the plane parallel assumption fluxes, BLITS uses a physics based approach that models three-dimensional fluxes through dense clouds.

## TECHNICAL APPROACH

1. Select several case studies from the Grayling I, Yuma, and Grayling II data base and prepare the input and validation data sets.

2. Generate solar and IR fluxes using several model techniques in order to explore the significance of the solar and IR fluxes in modulating the state of the ground. These fluxes will be calculated using a semi-empirical technique (using the work of Shapiro & Wachtmann), a plane parallel model (MODTRAN) and the more comprehensive AIM module.

3. Run SNTHERM for each case study for each set of fluxes generated as indicated in item three. In addition, run SNTHERM for each case study using the measured fluxes.

4. Compare the calculated fluxes and the ground sate for the model runs with each other and with measured data.

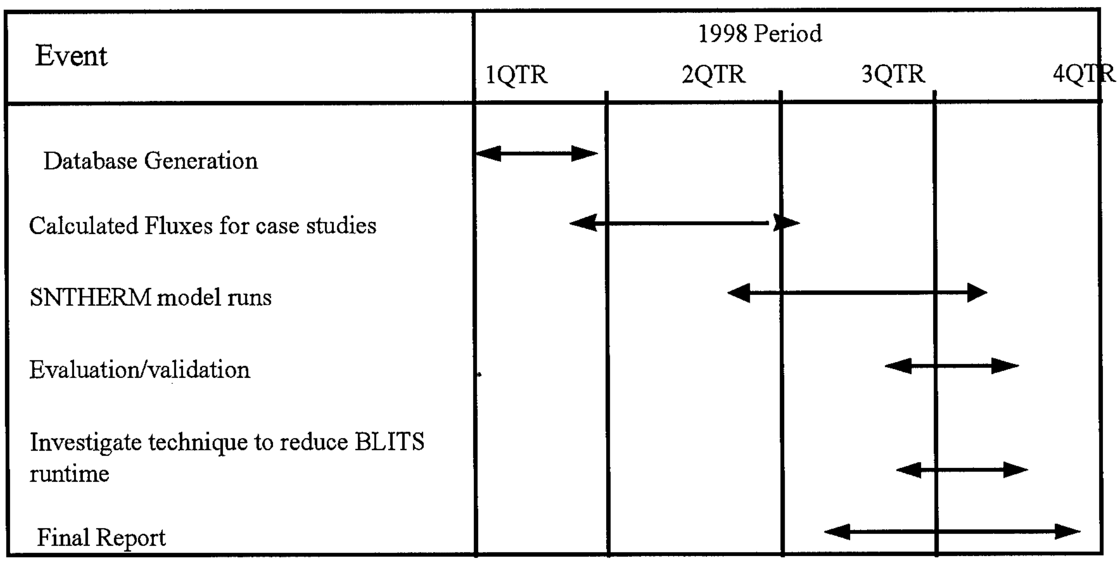
5. If AIM fluxes give the best results as anticipated, explore possible techniques that can be used to reduce the runtime of the model.

## PRODUCTS

1. An evaluation of the role of solar and IR fluxes in defining the state of the ground in cold environments.

2. A CRREL/ARL Technical Report.

## MILESTONES




## RISK/BENEFIT ANALYSIS

River flooding due to snow melt and impassable roads are just some of the impact cold environments can have on Army operations. The negative effects of cold environments was clearly demonstrated over the last two winters in Bosnia, especially during the first winter. But, forecast of the state of the ground, including the impact of snow melt on rivers stages, can be used to minimize or use to advantage the negative impact of cold environments on Army operations. To realize the full potential that modeling the ground state can have on planning and operations it is necessary to develop high fidelity models to forecast that state.

**EXECUTABILITY**

Existing CRREL and ARL technical resources and expertise will be used to determine the state of the ground for several cold environment scenarios. The model derived ground state will be validated using existing data bases. Alliances will be formed with programs like CRREL's AT42 plus up to revisit the state of the ground forecast for Bosnia, CRREL's synthetic environments effort, and PM Intel Fusion's Integrated Meteorological System (IMETS).

**PROJECT TITLE** **Using the FDB for Scenario Generation**
(Pending Funding Availability)

**STANDARDS CATEGORY** FDB

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**EXECUTIVE SUMMARY**

This project will demonstrate to the Standard Categories Coordinators (SCC) a methodology for using the Functional Description of the Battlespace (FDB) as a means to generate and organize data for the development of simulation (live, virtual and constructive) scenarios. The FDB can immediately support the electronic (via the internet) means to import data for the steps of building a scenario for use in training, research, and force development studies. Additionally, the FDB can provide support in the requirements definition and validation process of scenarios. This support is graphically depicted in Figure 1. The processes outlined in blue are the current FDB functions and demonstrate how the FDB can support the standards development process.

The FDB will provide a repository for data developed as well as complete traceability of all

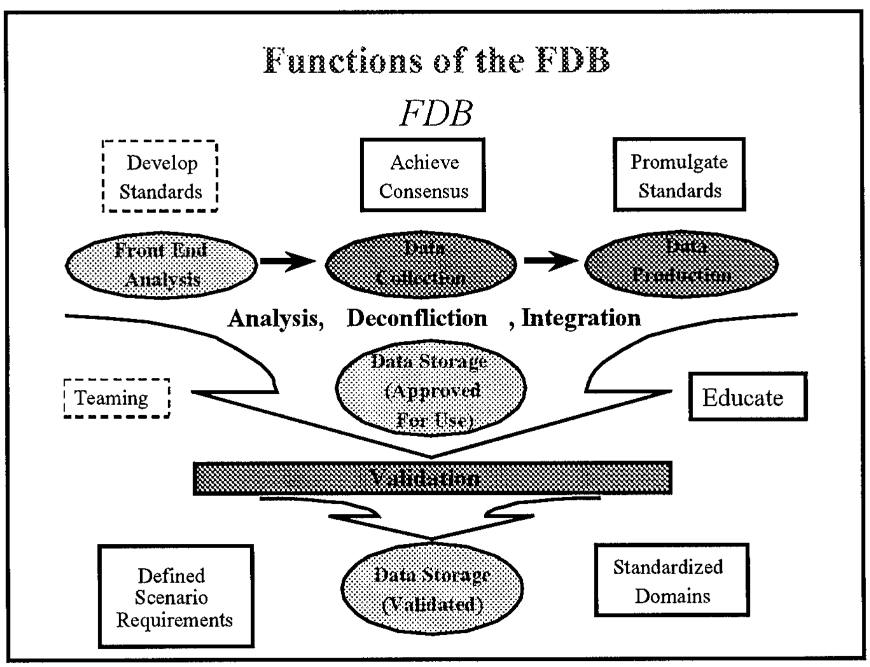


**Figure 1. Integration of FDB for Scenario Standardization**

pertinent data and models used for a simulation or mission scenario. This project will examine the use of the FDB for scenario generation for two cases in all simulation environments-constructive, virtual and live.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. The Army's M&S Master Plan extensively discusses the objective M&S environment. The central tenets of the objective environment are common use of applications and reuse of data. The current 19 standards categories represent centers of technological and procedural excellence. Their objectives are to develop and evolve Army M&S standards. In order to achieve these goals, the SCCs require an electronic repository for the data they produce and use. Currently, several different solutions are being applied by the SCCs. Many use local databases generated internally with very little discussion amongst other agencies. There is no central source to share data and ideas for scenarios. Also, the traceability of relevant data and models used for a scenario are often nonexistent.

2. The Functional Description of the Battlespace is a fully functional electronic data repository that is currently in use to support the development of WARSIM 2000. The FDB is a system that produces, documents and archives accurate, validated and trace-

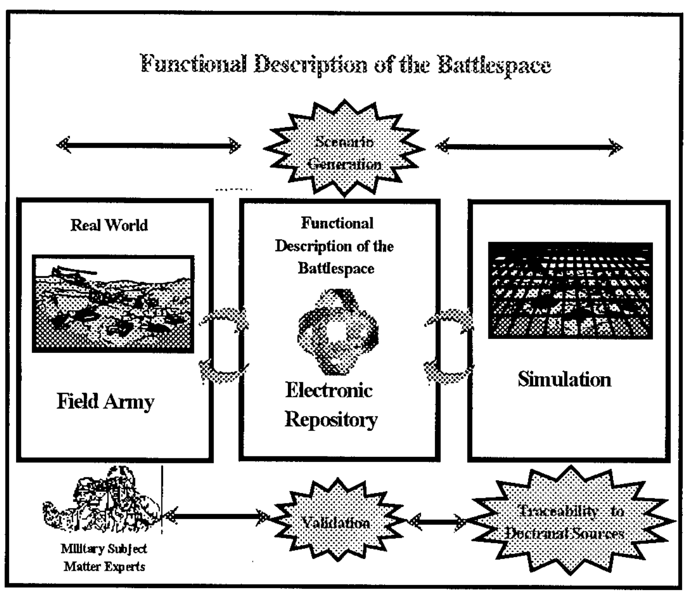


Figure 2. FDB's Role in Simulation Development

able standard descriptions of the components and characteristics of Army Battlespace functions. The FDB's goal is to become a linchpin that links the field Army in the real world to the environment of any simulation. This key role as it relates to Scenario Generation is demonstrated in figure 2. The same relationship exists for all simulations.

3. Widely known, updated and accessible software repositories provide a ready source of this information for users and developers and aid in spreading proven techniques and procedures throughout the M&S community. The FDB is such a repository. The FDB has the capability to accept data in hard or soft copy and provide the SCC cataloging service to include access, authorization and authentication, registration and release. In addition, the FDB offers the SCC a Forum by which users can provide comments on products and serve as the vehicle to validate information with the authorized data source. This process is currently being utilized to validate knowledge acquisition products developed for WARSIM 2000 by Lockheed Martin Information Services (LMIS). This same Forum provides the SCC with the means to manage the standards development process. The FDB provides a complete record of all transactions and as such provide the SCC with complete traceability throughout the life of the data. The data can be organized in a manner which enables collection of data and information for building scenarios. This project can demonstrate the facet of scenario generation support.

## TECHNICAL APPROACH

1. The Functional Description of the Battlespace (FDB) provides data and information useful in building scenarios for training exercises, research studies and force development analyses. The procedures for Scenario Generation include the following modules:

   A. Identify Training Objectives
   B. Define BLUFOR Structure
   C. Define OPFOR Structure
   D. Establish Theater of Operations
   E. Establish Commo Infrastructure
   F. Identify Logistics Environment
   G. Design Initial Intel Picture
   H. Identify STARTEX Positions

2. The information that the FDB provides will be able to populate these modules to allow scenario developers to maintain and use validated (for training only) data. In the case of a event which requires classified data, the appropriate future FDB configuration (classified, standalone or secure network) would have to be used.

3. For the prototype of generating scenarios from the FDB, several cases from all three types of simulations would be required. Ideally, a representative scenario from each domain (RDA, TEMO and ACR) would be preferred. Albeit, this project will only focus on using simulations from the TEMO domain with priorities of constructive, virtual, and live. As the FDB currently contains only unclassified data, this may restrict access to all three domains. The TEMO domain is the best one to start with. One scenario of unclassified data could be demonstrated for the other two domains if unclassified data is available. If

funds remain, efforts will be made to include the other two domains. However, the results and prototype should apply across all domains.

## PRODUCTS

- FDB Scenario Generation Plan
- Four (4) Quarterly Reports
- FDB-Generated Scenario for a Constructive Simulation
- FDB-Generated Scenario for a Virtual Simulation
- FDB-Generated Scenario for a Live Simulation
- Report of prototype use for generating scenarios in all Domains

An FDB Scenario Generation Plan will be developed under the auspices of this project. The plan will outline the support this specific project will provide to the SCCs. The project plan will be initiated immediately upon receipt of funds and will develop the detailed work schedule and timeline of deliverables. The plan will also provide for coordination with the other SCCs and simulation users to determine individual needs as well as brief backs to gain consensus before software changes are implemented. Provided as a management tool for AMSO will be four quarterly reports which will fully describe the status of the project. Specific format of the quarterly reports will be detailed in the project plan. The common deliverables are the FDB-Generated Scenarios. Each simulation targeted for scenario generation will be representative of both current and future systems in the U.S. Army. This project represents state-of-the-art in collecting, verifying, validating and storing information and data that supports the Army's M & S objectives. This effort achieves the goals as outlined in AR 5-11 in that they:

- ***Provide a common set of verified, validated and certified data which can be shared by Army Modeling & Simulation activities.***

- ***Improve data quality and accuracy and minimize the cost of data production and data maintenance IAW DoDD 8320.1, DoD Data Administration and DoD 8320.1 M, Data Administration Procedures.***

## MILESTONES

| Event | Date |
|---|---|
| Coordination w/ SCCs | TBD |
| Project Initiated | 01 Oct 97 |
| Initiate Scenario Generation Analysis | 01 Oct 97 |
| FDB Scenario Generation Project Plan | 31 Oct 97 |
| "Modified" FDB for Scenario Generation Complete | 30 Nov 97 |
| Back Brief to SCCs (via VTC) | TBD |
| Constructive Scenario Generation Complete | 03 Dec 97 |
| Quarterly Report (1ST Quarter 98) | 05 Jan 98 |
| Quarterly Report (2ND Quarter 98) | 06 Apr 98 |
| Quarterly Report (3RD Quarter 98) | 06 Jul 98 |

| Event | Date |
|---|---|
| Quarterly & Final Report ($4^{TH}$ Quarter 98) | 5 Oct 98 |
| Virtual Scenario Generation Complete | 03 Apr 98 |
| Live Scenario Generation Complete | 03 Jul 98 |

## RISK/BENEFIT ANALYSIS

The FDB Integrated Product Team can propose an extremely cost effective solution based on three years of dedicated development that has already gone in to this fully fielded system. The customer is only required to provide the resources to modify and show future potential of this successful program.

Overall, the project seeks to exploit potential for digital libraries in the military as not only repositories of information and data, but tools to build new products for simulations and other programs. The FDB is currently up and operating on the world-wide web and can provide access of data to authorized users. Modification of the current version will be performed by the same engineers who developed the FDB. The generation of scenarios will be conducted by experienced simulation users and developers. The experiences of both groups will ensure success of this prototype program.

## EXECUTABILITY

The FDB System Manager (TRADOC) and Material Developer (STRICOM) and will provide oversight and guidance. Veda, Inc, the FDB contractor, and another agency (to be determined) will provide project execution and management.

*AMIP-98-ARCH-01*

**PROJECT TITLE** **Using the HLA Object Model Template for Simulation Specification**

**STANDARDS CATEGORY** Architecture

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## EXECUTIVE SUMMARY

The High Level Architecture (HLA) Object Model Template (OMT) is a specification for documenting HLA-relevant information about classes of simulation or federation objects and their attributes and interactions. In other words, the current OMT provides "after-the-fact" documentation of simulation capabilities. The intent of the proposed research is to develop extensions to the HLA OMT that would enable its use as a method for simulation specification and design. The goal is that the OMT could also be used "before-the-fact" during the simulation specification and design process. This research would design, try out, and propose OMT extensions to support the use of the OMT Federation Object Model and Simulation Object Model (FOM/SOM) as a specification method. A simulation specification method based on the OMT would bring consistency to the overall development process, reduce the work required to achieve HLA compliance, and promote interoperability.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. The High Level Architecture (HLA) Object Model Template (OMT) is a specification for documenting HLA-relevant information about classes of simulation objects and their attributes and interactions. For the purposes of achieving interoperability, the OMT provides a specification of the exchange of all public data among simulation systems in a common, standardized format. The resulting "information model contract" is referred to as a Federation Object Model (FOM), where federation refers to the collection of interoperable simulation systems or federates. An HLA Simulation Object Model (SOM) is the result of applying the OMT to an individual simulation system. An HLA SOM is a specification of the external capabilities that an individual simulation could offer to potential HLA federations.

2. The intent of the proposed research is to design extensions or modifications to the HLA OMT that would enable its use as a tool for simulation system specification and design.

In both the FOM and SOM applications of the OMT, the emphasis is on documenting the capabilities of existing simulations systems in an interoperating environment. By turning this emphasis around, the HLA OMT could be viewed as general tool for specifying models and requirements. For example, instead of defining FOMs and SOMs from existing simulation systems in order to compose training exercises, the training objectives would dictate the composition of the FOM and SOM, from which the simulation would be developed.

3. Optimistically, a model developer could first specify an OM based on the natural requirements of the simulation objective (realistically, existing FOMs and SOMs would at least be used as guides if not building blocks). The OM would identify those objects/interactions and attribute/parameters that would best represent the environment. This "OM Specification" could then be used to compare against existing FOMs and SOMs for their suitability in satisfying the optimistic requirements. If there did not exist SOMs that satisfied the "OM Specification" requirements, then the requirements would be extracted into "SOM Specifications". These SOM specifications would guide the detailed specification of a new simulation system by the current specification methodologies.

4. The last stage of the Conceptual Model of the Mission Space (CMMS) Development Sequence calls for conceptual models which use the CMMS Technical Framework standards as formal Interface Design Descriptions. The proposed extensions to the OMT FOM/SOM would support these requirements providing smoother integration of design specifications with the CMMS.

## TECHNICAL APPROACH

The proposed approach consists of several steps:

1. Follow OMT and CMMS development.
2. Investigate existing simulation specification mechanisms and requirements.
3. Adapt those principles to the OMT, designing extensions to OMT
4. Disseminate draft extensions to simulation community.
5. Apply the modified OMT to develop specification and design documents for a simulation.
6. Based on use experience and community feedback, revise the OMT extensions.

## PRODUCTS

Technical report containing:

1. Proposed extensions to the HLA OMT needed to support the use of the FOM/SOM as a specification and design tool.
2. Use case analysis documenting a trial application of the proposed extensions.
3. Feedback provided by simulation community.

4. Recommended revisions to the OMT development tool software to support the proposed extensions.

## MILESTONES

| MAPS | Milestone |
|---|---|
| 4 | OMT Extensions draft report |
| 6 | OMT Extensions final report |
| 6 | OMT Extensions use case analysis final report |

MAPS = Months After Project Start

## RISK/BENEFIT ANALYSIS

Potential benefits of the proposed research:

1. Standardized, common simulation requirement specification method for HLA compliant simulations.
2. Consistent documentation format throughout simulation development cycle, from specification to compliance certification testing.
3. Smoother integration with CMMS.
4. Increased simulation interoperability and software reuse by virtue of common specification methodology.

## EXECUTABILITY

All work will be completed by the University of Central Florida Institute for Simulation and Training using existing STRICOM contractvehicles.

**PROJECT TITLE** **Vehicle Integrated Defense System(VIDS) Cost Performance Relationships (COPRs)**
(Pending Funding Availability)

**STANDARDS CATEGORY** Cost

**POINT OF CONTACT**
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## EXECUTIVE SUMMARY

The current defense acquisition "doctrine" is the idea of performing cost performance tradeoffs so that its force is "optimized" within current budgetary constraints. Supporting this process poses a significant challenge to cost analysts who must provide meaningful tools for the conduct of trade studies. Innovative estimating algorithms, plus a standardized approach for performing such analyses, needs to be developed. Technology cost performance relationships (COPRs) is one tool that can have a significant impact on how we meet the challenge. They provide the ability to estimate the cost of future technologies, based on varying levels of performance, with the ability to gauge the impact of performance changes on battlefield effectiveness. The dynamic nature of these algorithms, combined with their battlefield linkage, is a real leap ahead in traditional trade-off analysis. Such a tool would facilitate necessary trades required under the Cost as an Independent Variable (CAIV) strategy.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

Current budgetary pressures have led the Army to pursue a strategy of optimizing the operational capability of the total force for a given modernization investment. Cost as an Independent Variable (CAIV) describes an approach where a weapon system's performance and schedule become a function of available (budgeted) out-year resources. To achieve this "optimization of operational capability", cost performance tradeoffs are required during each phase of the acquisition process. To perform credible cost tradeoffs, accurate predictors of the cost of future technologies that may be considered for either system upgrades or future new start systems must be developed. The challenge is to develop an estimating algorithm that will allow for rational cost tradeoffs to be performed. Technology cost performance relationships (COPRs) are such a tool. They enable the user to estimate the costs of competing technologies as well as to assess cost impacts of varying technology performance (e.g. what is the cost of a radar warning receiver with a range of 15km? of 25km? of 30km?). Results enable the decision maker to make an assessment of whether the increased cost for a given capability is justified. This tool also allows "design" of technology options that fall within prescribed performance and cost thresholds. It is the critical trade space between threshold performance values and objective performance values that may yield the greatest cost savings to Army programs. Linking the cost and performance values of tradeoffs being considered, with their respective operational effectiveness (as provided by a battlefield effectiveness model) provides additional information to the decision maker. To summarize, the key elements of performing credible cost trades are quality estimating relationships and some way to measure the overall or component level effectiveness of varying levels of performance. In other words, what impact does a change in performance have on cost and e-ffectiveness? Not new concepts, but the rigor and timing of these tradeoff analyses dictate that new tools and techniques be developed.

## TECHNICAL APPROACH

COPRs will be developed for all new development technologies that form the heart of new or upgraded weapon systems. They will be developed to estimate costs for Research and Development (R&D) and Production cost drivers: development engineering, prototype manufacturing and production manufacturing. Because of their unique ability to estimate both cost and cost impacts of performance changes, COPRs are, in and of themselves, standalone tools which have widespread application amongst the Defense Acquisition community. They provide a data source for a variety of cost studies such as Program Office Estimates, and can be used to support such processes as Requirements Determination, technology development, wargaming analyses and CAIV. Also, because they are "standardized" algorithms, they can be readily incorporated into existing Army and DOD databases and models, such as the Army Cost Data Base (ACDB) and Automated Cost Estimator-Integrated Tools (ACE-IT).

Technology COPRs will be developed in a progressive fashion by work breakdown structure categories. TACOM Cost and Systems Analysis is currently utilizing contractor support develop COPRs for Lethality and Vehicle Integrated Defense System (VIDS) technologies. Under this proposal, we are seeking funding to continue with the VIDS effort. As they are developed, COPRs will be incorporated into a higher level trade-off model being developed in-house. This model, the Performance Affordability Assessment Model (PAAM), provides an automated, standardized approach for conducting cost-performance tradeoffs. PAAM enables trade-offs to be conducted not just as the component level, but also for complete weapon systems and force structures. PAAM is an architecture which walks the user through a series of menus to define the trade-off alternatives under consideration. The COPRs that populate PAAM's data base provide the ability to estimate technology cost. Utilizing a parametric approach, PAAM will have the ability to estimate total weapon system R&D and Production costs. Ultimately, a methodology will be incorporated to estimate Operating and Support costs. PAAM's output generator will then link cost/

performance data with battlefield measures of operational effectiveness, as modeled in wargaming models. In summary, PAAM will provide the decision maker with ample information to estimate, compare and rank tradeoff alternatives. It will also enable the user to make informed investment versus support decisions.

## PRODUCTS

A contract is already in place for the development of R&D and Production COPRs for a set of Vehicle Integrated Defense System (VIDS) technologies. Tasks on this contract are being completed in phases as funding becomes available. At the end of each contract phase, the contractor will deliver a data base of cost and technical information used to develop the algorithms. He will also publish a report documenting the COPRs. Both will be available for distribution, incorporation into other Army, DOD data bases or models.

## MILESTONES

Milestones are for continued development of VIDS COPRs. Significant accomplishments have already been made toward the development of Production COPRs. Work in the R&D area, and COPR - effectiveness linkages is ongoing, but not fully funded. Funding for this effort expires in March of 1998. Additional funding in the amount of $100K under this proposal would enable great strides toward completing this latter effort.

| *Events* | *FY97 Period* | | | |
|---|---|---|---|---|
| | **1QTR** | **2QTR** | **3QTR** | **4QTR** |
| Continued data collection, technology research, R&D. | ♦ | ♦ | | |
| Continued R&D COPR development. | | ♦ | ♦ | |
| Continued development of COPR-effectiveness linkages. | | ♦ | | ♦ |
| Delivery of data base. | | | | ♦ |
| Publication of report. | | | | ♦ |

## RISK/BENEFIT ANALYSIS

1. The risk associated with this project is small. The techniques being used to estimate costs represent accepted cost analysis methodology. The inherent risks are in the fact we are developing forecasts for future technologies that do not have a great deal of historical data. However, many of the sub-components which make up the VIDS technologies have application in other types of hardware, and data is available on them. The linkage between battlefield operational effectiveness and those variables which drive cost is another area that represents some risk to the development effort. Again, there has been some previous work in this area, and solutions appear to exist to solve this challenge.

2. The development of technology COPRs, as well as the ongoing development of the Performance Affordability Assessment Model (PAAM), will have a tremendous impact in advancing the concept of Cost as an Independent Variable. It links the cost and simulation worlds into a working tool that will allow cost performance tradeoffs to be performed as alternative technologies or systems are being considered. It will also work toward developing a standardized methodology for accomplishing such tradeoffs.

## EXECUTABILITY

A contract is already in place for development of VIDS COPRs. The contractor we are utilizing for the development of these algorithms has extensive experience and is recognized as highly competent by various DOD cost organizations. He has already proven his capability under this contract by successfully developing a set of Production algorithms during the first phase of the contract effort, and is aggressively forging ahead on his next set of tasks. Existing funds and the associated Period of Performance expire in March of 1998. We are pursuing FY98 funds to progress toward completion of the contract without a break in effort. Concurrently, actions are taking place to put additional option hours on the contract, so they will be available for execution in the event FY98 funding is received.

# APPENDIX E

## SIMTECH Proposals Approved to Receive FY98 Funding

**(sorted by Project Name)**

# APPENDIX E

## SIMTECH Proposals Approved to Receive FY98 Funding

**(sorted by Sponsoring Agency)**

| Sponsoring Agency | Project Title | Page |
|---|---|---|
| AMC | Development of a Data Collection and Analysis Tool Under the High Level Architecture Using Autonomous Agents | 209 |
| AMC | Mutual Enhancement of the Virtual Environment Database Server and the Soil Response Modeling Effort | 231 |
| AMC | Simulation Support Environments (SSE) for Army Modeling and Simulation (M&S) (SSEAMS) | 239 |
| AMC | Thermal Sensor Simulation in Near Real-Time (SWISS) | 251 |
| CAA | Comparative Simulation State and Path Research/Interpretation (SimPaths II) | 203 |
| MTMC | Interactive Data/Information Visualization Tool | 219 |
| MTMC | Port Simulation Model (PORTSIM) 3-dimensional Visualization System | 235 |
| OCAR | USAR Resources to Readiness (R2) | 257 |
| ODCSINT | Battle Command Process & Information Flow Representation | 199 |
| ODCSINT | Multi-Resolution Modeling (MRM) | 227 |
| OPTEC | Simulation Testing Operations Rehearsal Model - Visualization System (STORM-VS) | 243 |
| SMDC | Tactical Simulation Interface Unit (TSIU) Army Battle Command System (ABCS) Compatibility | 247 |
| TRADOC | A Federate for Data Collection and Analysis | 195 |
| TRADOC | Evaluating the Use of Combat Instruction Sets | 216 |
| TRADOC | Multi-paradigm Command Decision Modeling Architecture | 223 |

*SIM-98-TRADOC-03*

**PROJECT TITLE** **A Federate for Data Collection and Analysis**

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**EXECUTIVE SUMMARY**

We propose to develop a prototype of an Analysis Federate for data collection and analysis under the High Level Architecture (HLA). The Analysis Federate uses an HLA Simulation Object Model (SOM) of the data and provides federate services for data collection and analysis. The Analysis Federate can provide near real-time derived data during the simulation session and also allows for collection and exchange of such data after the distributed simulation session. This approach combines the best aspects of data logging and subscription and reduces the data logging requirements during the simulation run. Analysis Federate services take the form of extensible, reusable objects that collect, process and display data. This project will deliver a prototype of a HLA compliant federate for data collection and analysis, and a set of procedures and technologies for data collection in distributed simulations. The potential benefits of this work are significant since data collection is a universal requirement in simulation sessions. The requirement for a HLA compliant federate for data collection has been identified in several forums. All distributed simulations including the CASTFOREM re-implementation, OneSAF, and AWARS will potentially benefit from this project.

**BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM**

1. Data collection and analysis is a central issue in distributed simulation. This capability is critical to all Army domains: ACR, RDA and TEMO. It affects the conduct of studies, experiments and tests, and after action review. State of the art M&S technologies are required to effectively collect and analyze data from a distributed simulation session. The High Level Architecture in general and initiatives like the Standard After Action Review System (STAARS) in particular require this data collection capability, but no solution has been identified.

2. In conventional stand alone simulations data logging and post processing is built into and customized for the particular simulation. In Distributed Interactive Simulation (DIS) data collection was accomplished using network logging and built in simulation logging capabilities. Network logging produced unmanageable quantities of data, but this data was not sufficient for analysis. Correlation of multiple locally logged simulation data also failed to provide adequate information to analyze and reconstruct critical events.

3. HLA presents still more challenges for data collection in distributed simulation

sessions. Subscription to attributes and interactions must be selective since it is not feasible to log all network traffic. This requires tools to model the data to be collected, to subscribe and collect data, and to process this data. Additionally, there is an opportunity to provide processed data during the simulation session for interactive analysis and session management.

## TECHNICAL APPROACH

1. An Analysis Federate is an HLA federate designed to support data collection and analysis in the distributed simulation federation. The Analysis Federate is not a simulation, but serves as a placeholder for the collection of object attributes and interactions that support analysis in the distributed simulation. The notion of an Analysis Federate is in keeping with the HLA federate definition which includes simulations and other applications such as simulation managers, data collectors, live entity interfaces, and passive viewers.

2. The Analysis Federate subscribes to objects and interactions in the federation for data collection and subsequent analysis. For this purpose the federate adds nothing to the Federation Object Model (FOM); however, the Analysis Federate may also represent derived data in the federation. Derived data is obtained when data from the distributed simulation session is processed. Specific examples of derived data include statistical measures like "mean engagement range" and measures of effectiveness like "loss exchange ratio."

3. The Analysis Federate SOM is a model of the data obtained from other federates and of the data derived through processing.

4. To represent derived data we define an Analysis Federate HLA SOM. This SOM is a model of the elemental and derived data provided by the Analysis Federate. This federate can also provide near real-time derived data during the simulation session and will allow for collection and exchange of data after the simulation session. Analysis Federate data elements map to data elements in the FOM and potentially to data elements in other federate SOMs.

5. This work is based on the ideas presented in the 1997 Spring Simulation Interoperability Workshop paper number 122. The Analysis Federate we describe will be federated with one or more closed, stochastic, high-resolution, platform-based combat simulations. We propose to create an HLA SOM for this Analysis Federate and to describe the Analysis Federate services which will use this SOM to collect data and produce derived data. These services take the form of extensible, reusable objects that collect, process and display data. We propose to implement a prototype of this Analysis Federate to demonstrate this approach to data collection and analysis.

## PRODUCTS

This research will produce two products. The first is a prototype of an HLA compliant federate for data collection and analysis. The second is a set of procedures and technologies for data collection in distributed simulations.

**MILESTONES**

| | Oct 97 | Nov 97 | Dec 97 | Jan 98 | Feb 98 | Mar 98 | Apr 98 | May 98 | Jun 98 | Jul 98 | Aug 98 | Sep 98 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Object Oriented Analysis of Analysis Federate | | X | | | | | | | | | | |
| Develop Prototype Analysis Federate SOM | | | X | | | | | | | | | |
| Implement Analysis Federate Objects | | | | | | X | | | | | | |
| Implement HLA RTI for the Analysis Federate | | | | | | | | | X | | | |
| Conduct Distributed Simulation Experiments | | | | | | | | | | X | | |
| Document Analysis Federate Services | | | | | | | | | | | X | |
| Draft Data Collection Procedures | | | | | | | | | | | | X |
| Produce Final Report | | | | | | | | | | | | OCT 98 |

**RISK/BENEFIT ANALYSIS**

1. The benefits of this work will be significant. The requirement for a HLA compliant Analysis Federate has been identified in several forums. All distributed simulations including the re-implementation of CASTFOREM, OneSAF, and AWARS will potentially benefit from the research. The technical approach is low risk. The preliminary research is complete.

2. This project provides support for two Army standardization objectives. It directly supports the common M&S technical framework and it also supports the creation of an M&S infrastructure to meet end user needs. This project also supports priorities in several M&S Standardization Categories. In the Architecture category, data collection in HLA was identified as one of the top two priorities during the recent standards workshop. The Analysis Federate prototype and associated recommended practices produced by this research can become the basis for data collection standards in HLA. In the Object Management category, the Analysis Federate services will consist of a core set of objects that are potential candidates as standard data collection and post processing objects. In the Computer Generated Forces category, the Analysis Federate promotes the need for modular data and may serve as the basis for a generic post processing capability. In the Data category, the prototype Analysis Federate also serves as a generic data modeling tool.

**EXECUTABILITY**

Thirty percent of the funds will support work executed by Professors at the Naval Postgraduate School (NPS) on a reimbursable basis. A draft project proposal is on file. One or more NPS graduate students may contribute to this project and this work requires no funding. Sixty-three percent of the funds will be used to obtain contractor programming support through an existing general support contract at NPS. Seven percent of the funds will support travel by military analysts on the team. If this project is funded one third of the total work effort will be performed by mission funded military analysts and this work will require no funding.

*SIM-98-ODCSINT-02*

**PROJECT TITLE** **Battle Command Process & Information Flow Representation**

**POINTS OF CONTACT**


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## EXECUTIVE SUMMARY


Representing the command and control decision-making process in software is a critical and challenging task confronting the simulation community. Given this general statement, there is a need to represent the information flow of real-world C4ISR systems and their relationship to the commander and staff. In order to accurately portray the real-world in simulations, we must understand what processes are being executed. In addition, we need to identify when they are executed, what information is required, what is the timeliness of the information required, who needs that information, how is the commander and staff overloaded by information, and a host of other questions relating to staff processes. Currently, there is not a standard methodology for representation of these dynamic staff and commander functions. This effort will use a standard COTS queuing package (OPNET) to research methodology for representing generic battle staff functions. The battle staff functions at various echelons, for various functions, and for foreign as well as U.S. forces will be considered to assure the methodology is sufficiently robust. With the application of this type of technology, the M&S community can readily understand what level of representation must be provided within simulations such as WARSIM 2000 and JWARS to accurately represent battle command processes and their relationship to C4ISR.


## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

Representing the command and control decision-making process in software is a critical and challenging task confronting the simulation community. Given this general statement, there is a need to understand the information flow of real-world C4ISR systems and their relationship to the commander and staff. In order to accurately portray the real-world in simulations, we must understand what processes are being executed. In addition, we need to identify when they are executed, what information is required, what is the timeliness of the information required, who needs that information, how is the commander and staff overloaded by information, and a host of other questions relating to staff processes. Currently, there is not a standard methodology for representing these dynamic staff and commander functions.

## TECHNICAL APPROACH

1. This effort will use a standard COTS queuing package (OPNET) to research methodology for representing generic battle staff functions. The battle staff functions at various echelons, for various functions, and for foreign as well as U.S. forces will be considered to assure the methodology is sufficiently robust. A prototype will be developed based using the Functional Description of the Battlespace repository. Sources that will feed this effort include but are not limited to; the Army's Operational Architecture, WARSIM 2000 knowledge acquisition products, SIGCEN realistic communications modeling efforts, NGIC foreign forces data bases, and previous efforts to examine foreign artillery behaviors.

2. The prototype will provide a comprehensive set of dynamic layered views representing the relationships between the battle command process and the C4ISR architecture.

   A. A functional model, which reflects command and staff responsibilities and the way in which the people who use the system view their work.

   B. A process model, which details the commander and staff functions of the TOC (e.g. receive orders, develop estimates, determine COA, manage resources, issue orders). In this way issues between the functional structure and process model can be examined.

   C. An information model, which details the information that the commander and staffs need to function.

## PRODUCTS

A technical report detailing the representation methodology developed and a prototyped model/tool will be delivered.

## MILESTONES

| | Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Milestone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Methodology Development | x | x | x | x | | | | | | | | |
| Model Architecture Design | | | x | x | x | x | | | | | | |
| Development of Prototype | | | | | x | x | x | x | | | | |
| Prototype Analysis and Testing | | | | | | | x | x | x | x | | |
| Finalize Results and Deliver Report & Prototype Tool | | | | | | | | | | x | x | x |

## RISK/BENEFIT ANALYSIS

1. The application of this technology will have far reaching benefits and will be able to answer questions relating to sensor to shooter timing issues, overloading of staff elements, critical task path identification, staff organizational issues, load balancing issues for simulation development, etc.

2. Another potential use is for reengineering of the organizational processes, alignment of personnel based on workload, connecting the right processes and technology with warfighting strategies to achieve synergism. This can be thought of as taking a TOC/unit in its current state and forming an organizational and operational blueprint to redirect skills, policies, information (data), organizational structures, and processing technologies.

3. Commanders can also utilize this tool to estimate the completion time of staff products, when to expect a given staff product, and what are critical processes. As an example, the commander might specify a plan of action and then ask the question: How long will it take to execute this plan? This tool could be used to model timing requirements associated with coordinated troop activities. With the ability to predict a plan's execution time, a commander can compare alternative plans and include time constraints in the decision process. Other questions a commander may ask about a specified plan of action are:

   - Is this plan valid? (e.g., is doctrine followed? is chain of command maintained?)
   - Are there enough resources? (e.g., tanks, ammunition, troops)
   - Is the plan achievable? (e.g., troop coordination, time constraints, required permission)
   - Which events must or must not occur to guarantee mission success?

## EXECUTABILITY

AMIP funding will be used to provide contract support in developing the decision making model in OPNET. The Functional Description of the Battlespace Team and LMIS Knowledge Acquisition Support Team will provide additional support and assistance in model population. This initial prototype/proof-of-principle will focus on modeling the Bde through Co level staff planning process. The methodology developed will help to validate the FDB as a source for modeling the Army and will facilitate the identification of shortfalls that might exist.

| | | |
|---|---|---|
| Contracts | 90% | Existing support contracts with NSC. |
| . | | 100% of funds will be used for contract support |
| In-House | 10% | NSC, DCSINT, and NGIC Oversight |

*SIM-98-CAA-01*

**PROJECT TITLE** **Comparative Simulation State and Path Research/ Interpretation (SimPaths II)**

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## EXECUTIVE SUMMARY

The proposed collaborative research merges and builds on several promising lines of work (by Drs. Gilmer, Robinson, and Taylor) including earlier SIMTECH projects and is focused on selectively generating, capturing, interpreting, and exploiting multiple paths or trajectories through the state spaces of combat simulations. The proposed collaboration is an outgrowth of a meeting of minds at a March 1997 Analytic Combat Modeling and Simulation Workshop co-hosted by the Army Research Office (ARO) and CAA. Normal simulation practice, whether deterministic or stochastic, is to generate a single path per "run." CAA applies a hierarchy of combat simulations; higher resolution models "feed" lower resolution ones. A long-standing goal is to capture sufficient data from engagement simulations at high resolution to extrapolate or interpolate to lower resolution ones with statistical fidelity. Despite enormous increases in CPU power, it is impractical to generate all possible engagements and combat trajectories at high resolution. Hence, it is necessary to "manage" trajectory generation and exploration within and among runs for later extrapolation in accord with notions of necessity, sufficiency, and feasibility ... and efficiency. This project brings together emerging approaches for managing multiple trajectories within and among methods, models, and runs. The university research is to be performed at the Naval Postgraduate School and through ARO by faculty and students of Wilkes University and the University of Wisconsin. Dr. Gilmer is to continue his research on following several different, maximally informative simulation paths within a "single run." Dr. Robinson is to develop a "dual variable" approach appropriate for formalizing the selection of postures, the allocation of targets, assessment of attrition, and unit movement to replace one or more current informal, intuitive, heuristic, and/or ad hoc schemes. In the mean time, Prof. James Taylor is to continue his comparison of the theories and practices of "competing methods."

## BACKGROUND/DESCRIPTION OF THE PROBLEM

1. The theater campaign analyst faces enormous difficulties. Theater simulations tend to be large. Serious analysis demands attention to troubling uncertainties as well as many friendly and threat alternative courses of action. Practical campaign analysis forces tradeoffs between scope and resolution, between deterministic and stochastic modeling, and between comprehensive run sets and timely results. CAA's approach to the weapon system attrition scope/resolution dilemma has been to use replications of a limited (division/brigade) scope, high resolution stochastic simulation to calibrate attrition for

theater level deterministic simulation. A recent CAA theater campaign analysis included more than 10,000 red or blue attacking engagements at blue full or reduced brigade level. CAA believes that campaigns are intended to achieve and exploit differential effects and that realistic simulation demands representation of a wide range of non-standard engagements. The engagements of interest are non-standard with respect to weapon and target levels, mixes, and densities and become non-standard by design and by accident. The campaign battlefield is seldom a place of perfect proportions. The art and science of war involve compelling opponents into non-standard situations. Meaningful simulation demands representation of both standard and non-standard engagements.

2. Dr. Gilmer (Wilkes University) is in the second year of research to investigate the applicability of "multitrajectory simulation techniques" to force-on-force combat simulations. Multitrajectory simulation follows two or more outcomes of a random event, instead of only a single outcome determined by chance as is the usual practice for a single replication of a stochastic simulation. Gilmer's method follows and preserves many trajectories or paths and their associated probabilities through simulation state space. For small simulations, the approach may track all paths. However, for real problems the modeler's primary challenge is controlling and constraining the potential combinatoric explosion by a managed sampling approach. In principle, best management should provide a maximally informative trajectory set -- or, if not maximal, a set that provides the information necessary and sufficient to support conclusions or to feed another step of simulation in a modeling hierarchy. Dr. Gilmer's goal is the generation of trajectory bases that span the entire engagements domain of interest.

3. Dr. Robinson (University of Wisconsin) and his students have studied the marginal values of combat systems in order to improve decision-making about the designing and equipping of a force. The work formalizes and extends classic notions of shadow pricing. In principle, similar notions may be moved "inside a simulation" to influence battlefield choices and decision-making about posture, target allocation, attrition, and movement -- i.e., trajectories in combat state space. Hence, there is an opportunity to relate the work of Drs. Gilmer and Robinson.

4. On the surface, Gilmer's work emphasizes values of primal battlefield quantities, and Robinson's work emphasizes dual variables. In the abstract, Gilmer generates and follows paths or trajectories in the primal space by selecting from among the subset of tangents from a tangent space defined on a primal base space. In principle, the choice of tangents may depend on the application of a varying dual form also defined on the primal base space. It is expected that Gilmer and Robinson can benefit from each other's work by unifying their workspaces.

5. Prof. Taylor has been working to develop a framework for objective description and comparison of candidates for the jobs of determining postures, target allocations, attrition estimates, and unit movements. In FY97, he has been building the framework to include considerations mainly in terms of the underlying primal spaces and variables and applying that framework to the comparison of three long-standing approaches:

ATCAL (e.g., CEM), Antipotential-Potential (e.g., TACWAR), and Bonder-Farrell (e.g., VIC). Taylor's continued research is intended to extend his framework to consideration of dual measures and application to a still larger set of approaches.

6. This proposal extends and integrates the work of all three researchers to the point that practical application at necessary and sufficient scope and resolution is possible.

## TECHNICAL APPROACH

1. The continuation of Gilmer's work is proposed to extend those aspects explored during the first two years' effort, principally: (1) State Distance Metrics: One of the techniques for keeping the number of trajectories manageable is to recognize when two states are very similar. It was found that a small minority of the supposedly "similar" states, if actually followed, diverged rapidly from the supposed representative. Others were quite well behaved. This suggests that a better metric, which more accurately predicts whether two trajectories will diverge or not, is needed; (2) Trajectory Choice Policy: Current choice policies are structured to favor the most likely outcomes when resource limits are reached, but this can result in missing interesting but less probable trajectories. More advanced choice policies need to be explored that will allow tradeoffs between outcome space coverage and coverage of the possible variety of "interesting" cases; and (3) Scalability: As scenario size varies, given computational resources that are constant or perhaps vary linearly, how well does the multi-trajectory approach perform in terms of giving the analyst an understanding of the potential outcomes of the scenario? And to what extent do outcomes provide sufficient bases for representing engagements at greater or lesser scales?

2. Even small simulations may involve a wide variety of decisions. The means by which the current generations of simulations "choose" have diverse origins. Many share the feature of assigning figures of merit or values to options and then choosing the option (or options if the approach is multitrajectory) that has the score that is best in some sense. The figures of merit may be static or dynamic, local or global. They may have come from a panel of experts, from an oracle, from an historical analysis, from a heuristic subroutine, or any of many other sources that analysts of all ages have suggested or invented. Ideally, all such values should be relatable to short and/or long term objectives and to abstract dual spaces. Not surprisingly, different uses and different purposes almost always should imply different dual variables and different values. Dr. Robinson has studied what are considered the classical works on linear weights, all basically derived from eigenanalyses of linear algebraic systems. Dr. Johnsrud introduced a method for determining killing system values that can vary from engagement to engagement within a campaign; his approach effectively applies a nonlinear eigenanalysis. Prof. Stiller (of Texas A&M) compared linear and nonlinear methods. Dr. Robinson has done original work on marginal values and shadow prices (or, generally, dual variables) for combat systems primarily with a focus on influencing system and unit design. In a sense, the viewpoint depends on engagement outcomes but involves value determination "outside" the engagement. The proposal is to move dependence on dual variables "inside" the engagement. Based on his earlier work with

relatively small test problems, Robinson concluded that "application to actual Army engagement models is probably now feasible, but computational methods still need improvement." Robinson already has significant experience in numerically solving variational inequalities, a task central to success.

3. Overarching the foregoing is a larger problem: How does one tell which of two or more competing approaches is superior? The ongoing, heated arguments about what method or model to use show that the matter is far from resolution. In late 1996, Prof. James Taylor, as broadly and deeply familiar with military modeling as anyone, agreed to apply his expertise to the development of objective criteria for choosing among methods and models. Taylor categorized himself as much more knowledgeable with respect to what is mentioned above as primal variable modeling but acknowledged the importance of including dual variable consideration. In the event, the scope of his FY97 effort was limited to development of a primal variable framework and application of that framework to just three example modeling approaches. For FY98, the framework is to be extended to included dual consideration and is to be applied to additional examples. Interaction among Gilmer, Robinson, and Taylor will provide the kind of interdisciplinary catalyst needed to solve each's problem and produce effective conceptual and practical integration.

4. The modest request for OPA should not be considered a stopper. At this stage, it is hoped that all researchers, including CAA, have enough hardware and software to complete their work. The request is stated as a contingency shield in the event that any new need for, for example, more RAM or more disk space may arise. The possibility of a combinatorial explosion of trajectories is noted above; that might increase the need for on line workspace.

**PRODUCTS**

1. Gilmer and Robinson are to develop algorithms and code and fully brief and document their work. They are to discover and report probable practical limitations on addressable modeling scope and resolution. No complete new models are expected. However, the developed guidelines and examples may form the basis for modifying existing simulations and processes or for influencing specifications of new modeling efforts. The target community is that of analytic modelers, who must achieve simulation speeds of 1,000 to 10,000 or more than real time and who must complete design sets of hundreds of runs within a few weeks to a few months at most -- basically, modelers who cannot afford to do everything at high resolution.

2. The generation and management of multiple simulation state trajectories is also relevant to formal, explicit planning methods (as in the searching of possible futures) and to treatment of virtual time (as in optimistic parallel computing paradigms, such as Time Warp).

3. Taylor's products may be viewed as: (1) a generalized blank spreadsheet in which rows correspond to primal, dual, and other criteria and in which columns may correspond to

different approaches (e.g., ATCAL, APP, Bonder-Farrell, etc), (2) documentation on how to fill in the cells of the comparative spreadsheet, and (3) a spreadsheet completed for some set of approaches of interest (to include the results of Gilmer/Robinson collaboration).

**MILESTONES**

1. IPRs and phone and email contacts will continue. IPRs typically are set so as not to conflict with researchers' classroom commitments. ARO and CAA may co-host a workshop early in 1998.

2. The plan is for two generations of documented products within the FY -- in Feb98 and Sep98.

3. Depending on emerging results, decision will be made in Jul/Aug98 whether to continue research into FY98.

**RISK/BENEFITS ANALYSIS**

1. There are obvious theoretical and practical problems. The proposed research introduces abstractions far beyond those common within the modeling community. To date progress has been encouraging but modest. Although complete success is problematic, at best, the proposed work will almost certainly provide significant improvements in the theory, practice, and understanding of deterministic, stochastic, and hybrid simulations. Such improvements are needed most for hierarchical modeling families in which only a relatively small number of simulations of higher resolution (standard) engagements must provide the conceptual and computational bases for interpolation/extrapolation for hundreds to thousands of lower resolution (non-standard) engagements.

2. The principal investigators are internationally known; the researchers are of the highest quality.

3. The state and path spaces of large simulations are enormous. Even the best achievable path management and extraction will leave much unknown and unrepresentable. The risk is that Gilmer's promising methods may fail before models much larger than toys are addressed. At the least, Taylor's research should reveal much about the domains of applicability and relative merits of many simulation practices and results.

**EXECUTABILITY**

1. The Army Research Office is prepared to handle funding for Drs. Gilmer and Robinson. ARO will apply its standard monitoring, review, and reporting requirements. The Naval Postgraduate School is prepared to accept funding directly from AMSO.

2. Almost all the actual research is to be performed by the University PIs and their grad students. CAA modelers will participate in providing examples for consideration and in reviewing the researchers' work. As appropriate, CAA's Army High Performance Computing Research Center (AHPCRC) site representative will coordinate access to special high performance computing platforms available within the DoD HPC community.

*SIM-98-AMC-01*

| | |
|---|---|
| **PROJECT TITLE** | **Development of a Data Collection and Analysis Tool Under the High Level Architecture Using Autonomous Agents** |
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## EXECUTIVE SUMMARY

The emergence of High Level Architecture (HLA) as the standard for simulation interoperability has created the need to develop software tools and techniques that operate in an evolutionary new environment. Data collection and analysis are fundamental components for all modeling and simulation (M&S) activities. While HLA seeks to improve interoperability for large scale distributed simulations through the use of new technology, the data collection and analysis requirements present a unique set of problems and limitations.

This project applies the emerging technologies of autonomous software agents to problems associated with data collection, synthesis, and analysis in HLA. These agents will make use of the "remote programming" paradigm - transmitting a program to a remote machine or server where the program is executed one or many times. The use of autonomous agents in data collection will allow adaptive, distributed, and coordinated data retrieval across the entire fabric of a widely distributed simulation experiment causing minimal interference with the virtual world.

Missile Research, Development, and Engineering Center (MRDEC) has developed a data collection and analysis tool (DCAT) that has been proven effective in the distributed interactive simulation (DIS) environment. In the proposed project, this code will be enhanced to utilize autonomous agents. The resulting tool will be useful for large HLA experiments because it will address potential HLA run-time interface (RTI) bandwidth limitations.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. **Purpose of Data Collection**

   A. Data collection within a distributed simulation exercise is done for exercise analysis or replay. Exercise analysis may concentrate on the behavior of a particular simulation component, or the aggregate behavior of a collection of components. This analysis can be used to assist the simulation model verification and validation process. Data collected during the simulation execution can also be used to evaluate performance of individual simulations.

B. A key benefit of data collection is the ability to review or replay a portion of the exercise at various levels of detail. A causal investigation of a particular event may be required to discover why or how something happened. Analysis or replay is usually only supported after the exercise is completed, although a data collection system can be designed to provide data queries during execution. This capability is useful to monitor the simulation execution in order to provide corrective actions when necessary.

2. **Existing Data Collection Techniques**

A. Data collection tools for large distributed simulation exercises have predominately used a logging mechanism. A logger monitors all simulation network traffic and stores the data as it is received. SIMNET, DIS, and ALSP-based exercise loggers are able to listen to the data broadcast between the participants and receive all data that is transmitted. A single logger is used to capture all of the data as the required rates are usually low enough for all simulation participants to receive all of it.

B. The tool that will be utilized for this project is the Data Collection and Analysis Tool (DCAT). It was developed at MRDEC to support analysis during and after DIS exercises for the Rapid Force Projection Initiative (RFPI). It provides real-time analysis of user-definable measures-of-effectiveness (MOEs), network analysis, and attrition rates, as well as post processing of exercise data. The effectiveness of this tool has been proven in exercises such as the recent Light Digital Tactical Operations Center (LDTOC) Battle Lab Warfighting Experiment (BLWE) and by other users such as Test and Experimentation Command (TECOM), several Training and Doctrine Command (TRADOC) Battle Labs, and the United States Marine Corps (USMC). Numerous agencies such as Aviation and Troop Command (ATCOM), Communication and Electronics Command (CECOM), Tank and Automotive Command (TACOM), the United States Military Academy (USMA), and Space and Missile Defense Command (SMDC) have expressed an interest in obtaining the tool.

3. **HLA Data Collection Issues**

The HLA offers some advanced capabilities to the simulation community and more importantly provides a common structure to enable interoperability and promote reuse. However, some of these capabilities and mechanisms present complications or trade-offs that must be overcome by the data collection system. The trade-offs and limitations imposed by HLA include:

A. **User Defined Federation Object Model (FOM).** Unlike previous simulation protocols used to support interoperability which define fixed representations for the data exchanged between simulations, the HLA allows federation specific data structures to be defined. Each simulation participating in an exercise must comply with a common FOM. The FOM specifies the structure of the data to be exchanged between the simulations, in the form of object or interaction classes. The HLA Run Time Infrastructure (RTI) uses a run-time typing mechanism in which an attribute is given a unique handle. A simulation that receives attribute data from another simulation is provided a handle and stream of bits that must be interpreted according to rules for that attribute. A data collection system that needs to support queries efficiently needs to decode the structure of the attributes and insert this data into a database based on a pre-defined schema. This requires the data collection system to be developed in connection with a specific FOM or be designed so that it can handle different FOMs in a manageable fashion.

B. **Scalability**. A major factor in scalability for large distributed simulations is the ability to provide each simulation with only the data it requires. Multicast communication technology is exploited by the HLA to achieve scalability by creating multiple communication channels that carry specific information for individual simulations and can be used as filters to obtain only the data that is needed. A consequence of the HLA data distribution techniques for a data collection system is that a single machine is incapable of collecting all of the data in a large exercise.

C. **Subscription**. Each simulation participating in an HLA exercise must subscribe to the types of data it wants to receive during execution. If the data collection tool does not subscribe to all required data for analysis, the data will not be provided and the analysis will be incomplete.

D. **Transmission Control**. Data publication and subscription in the HLA are monitored to ensure that there is interest in particular data before it is transmitted. The effect of transmission control on a data collection system depends on whether the system intends to passively or actively subscribe to the simulation data. If the data collection system needs to perform passive subscription, it is possible that if none of the simulation participants have subscribed to a specific data item, that data will not be captured, thereby resulting in incomplete data coverage.

4. **Autonomous Agents**

A. A software agent is a piece of software which acts to accomplish tasks on behalf of its user. Many agents are based on the idea that the user need only specify a high-level goal instead of issuing explicit instructions, leaving the how and when decisions to the agent. As listed in a paper by O. Etzioni and Dan Weld, appearing in IEEE Expert, July 1995, software agents have the following qualities: they are autonomous, goal-oriented, collaborative, flexible, self-starting, communicative, adaptive, and mobile; and they provide temporal continuity and character.

B. While it's not possible to summarize all functionality of all autonomous agent systems briefly, some aspects of autonomous agent systems are fairly universal. Autonomous agent languages are usually general-purpose, often a variant of C or C++ with functionality such as pointers removed. So, when using such a language, the functionality of an individual autonomous agent can be arbitrarily complex. Autonomous agents are "pushed" by their own behavior to local hosts which have agreed a-priori to participate in execution of the autonomous agent system.

C. The benefit of incorporating autonomous agents into the data collection process is a reduction in the amount of data passing through the exercise network. With the conventional data collection approach, many distributed sites are competing for throughput of ALL non-specific simulation data. The proposed approach results in using autonomous agents to intelligently pass ONLY the simulation data requested by the subscriber. A tool of this type would be of interest to any agency conducting widely distributed HLA exercises for analytic purposes where bandwidth limitations and physical distances inhibit success. The increasing costs for sending analysts and hardware to remote sites for exercises are a prime consideration for using software agents instead. Finally, the autonomous agents are highly adaptable to changes in exercise and network configurations.

## TECHNICAL APPROACH

1. Develop Autonomous Agent Control Station - The autonomous agents must be informed of the objectives for the data collection. The objectives for data collection are effectively the essential elements of data required to answer the question at hand. These essential elements of analysis (EEA) are determined by systematically decomposing the study objectives into study questions, then decomposing the study questions into MOEs, and then decomposing the MOEs into the EEA. After the EEA are determined they must be mapped into the FOM to insure all data elements are available in the FOM. Once this is accomplished, the autonomous agents can be given the goal of collecting the EEA. This process will be automated in the autonomous agent control station where the FOM is used in conjunction with the study questions to derive the EEA and then establish the goals for the agents. The control station will then act as a launch point to distributed agents across the network to collect the required data.

2. Develop Autonomous Agents - The autonomous agents will need to be developed and provided with their required abilities. To minimize development time, commercial-off-the-shelf software (COTS) tools will be used to build the agents. The autonomous agents must posses the ability to migrate across the network; to make decisions regarding cloning, destruction, and data collection; and to report data to a central collection point without using the RTI.

3. Develop Data Repository and Analysis Tool - Periodically the agents must update a centralized database with the data they have collected. This requires the development of a data repository and a schema for storing the data in a useful format. Once the data is collected in the repository analysts can mine the data to determine the MOE and

ultimately the answers to the study questions. To accomplish this requires the development of an object oriented database, a database schema, and a data mining tool with data visualization capability. The DCAT will be leveraged to provide the genesis for these components.

4. Verify Performance of Agents and Tools in HLA Exercise - Finally, the tools and agents will be tested to ensure reliable operation in a heterogeneous networked environment.

**PRODUCTS**

A complete data collection and analysis software package for HLA that minimizes the impact on the RTI, minimizes network loading, maximizes flexibility, and makes optimum use of the distributed nature of HLA exercises.

**MILESTONES AFTER CONTRACT AWARD (C)**

- (C+60d) Completion of the Autonomous Agent Control Station.
- (C+210d) Completion of the Autonomous Agents.
- (C+270d) Completion of the Data Repository and Analysis Tool.
- (C+330d) Completion of Testing.
- (C+360d) Delivery of executable software and documentation.

**RISK/BENEFIT ANALYSIS**

Risk is moderate and benefits are high. Most development tasks leverage previous work in the field and/or COTS tools and software. The HLA RTI version 1.0 is now available as are a number of developmental FOMs. There have been no previous uses of software agents in the HLA problem domain and the technology is still young but maturing rapidly. The availability of an automated tool for developing data requirements and then enabling the collection of that data in an automated way is a powerful weapon long sought by analysts. In addition, the tailoring of the software agents to the requirements of the study should combat the malaise of over-collection of data while still answering the fundamental questions.

**EXECUTABILITY**

Thirty percent of this effort will be performed in-house. The remaining seventy percent will be placed on an existing time and materials contract that is in effect until 2000 and has a scope of work which permits the work described above to be performed.

*SIM-98-TRADOC-01*

**PROJECT TITLE:** **Evaluating the Use of Combat Instruction Sets**

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## EXECUTIVE SUMMARY

This project provides a means for evaluating individual/sequences of combat instruction sets (CISs) in a rapidly changing simulated combat environment. The mission of the combat will be expressed in concise terms that includes not only the most desired outcome, but also the relative worth of each of the significantly different outcomes. Phase 1 uses the Valuated State Space Approach to express these alternative outcomes in terms of the parameters of concern, their relative importance, and degree of criticality, each being measured in an appropriate manner. This provides a basis for scoring the current situation and any possible outcome. It can then be used to evaluate alternative tactics while facing an intelligently interactive enemy. Phase 2 will explore a range of military situations wherein friendly and enemy forces interact in an arbitrary environment, each having different missions. This simulation will use ModSAF to represent the position, movement, and dynamics of individual tanks in tank platoon warfare. ModSAF is a good candidate for establishing a platform for this capability, since OneSAF (the next generation semi-automated forces) will not be available until 2001-2003. Evolutionary Programming will be used to discover optimal tactics at each point in time, given the available resources/capabilities and associated dynamics/ constraints, taking into account the presumed enemy's mission, capabilities and level of motivation. Experiments will be conducted wherein randomly selected tactics will be evaluated and improved through iterative mutation and selection. Specific combat instruction sets will then be inserted into the population to compete with those randomly generated. If they are superior, they will become the tactic of choice. If not, the superior tactic will emerge, together with a rationale.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. Conventional wisdom is bottom-up. We remember tactics that were useful in the past and establish doctrine that is presumably helpful over a wide range of situations. But, it is dangerous to refight the last war. We now face a new enemy with different missions and new capabilities. Our best move may have never been experienced in the past. Indeed, the use of combat instruction sets may prove to be a limitation of our capability. In fact, the reason our military force has been so effective in the past is that it is unpredictable. The Soviet military provides an outstanding example of excessive rules and doctrine. They are centrally controlled and predictable.

2. On the other hand, in real-world situations, the number of possible moves is enormous. Our troops cannot list the possibilities, no less find the best one at each point in time.

There is, however, a compromise that is now available through the use of Evolutionary Programming, a highly efficient technique for searching the domain of possible behaviors. This technique has been demonstrated in a wide range of settings including real-time mission planning for cruise missiles (under contract to Applied Physics Laboratory/JHU) and for generating a non-rule-based intelligently interactive adversary for training (this, under contract to STRICOM). Other applications of the Valuated State Space and Evolutionary Programming are under contract with the Naval Warfare Assessment Division, and the Army Medical Research Command. This technique has also been demonstrated for drug design (for Agouron Pharmaceuticals, Inc.), for adaptive control of freeway ramp signals (CalTrans), for maximizing the production of clothing (Levi Strauss & Company), for aiding decisions concerning the detection of breast cancer.

3. It is important to determine the extent to which combat should be rule-based and to evaluate the specific rules and when they are appropriate. Here is an opportunity to measure their worth in the context of simulated combat. This demonstration may have immediate application in the field and will be of direct value to OneSAF. OneSAF is required by the Department of Defense to develop and evaluate modern operational concepts, and to provide high quality and realistic training.

## TECHNICAL APPROACH

A combat instruction set indicates specific behavior. The value of that behavior depends the mission, for means have value only in terms of ends. If the mission has changed, the same behavior has different worth. The value of combat information sets is therefore, difficult to determine. The selection of CISs is enormously difficult. Even if they could be measured in worth, there are too many combinations for an exhaustive search. The task is therefore, to search the domain of possible tactics (inclusive of the CISs) to find the best tactic, given the current situation and mission. This can be done through Evolutionary Programming. The original population includes suggestions or recommended CISs and, in addition, randomly structured feasible tactics. Each of these is scored with respect to the mission. Only those of adequate value are mutated to produce offspring. The process of mutation and selection is iterated until a tactic of adequate value has been found. This is implemented or offered as a decision aid. The entire population serves as the progenitor for succeeding generations in preparation for the next decision. If any recommended CIS is indeed most appropriate, it will survive the competition. If not, a more appropriate tactic will be found, together with a rationale for its choice. The Valuated State Space Approach provides the required concise expression of the mission. Evolutionary Programming provides for an efficient search of the possible moves in light of that mission. Here is a way to evaluate individual CISs and, more importantly, find the most appropriate mode of behavior in a complex uncertain environment, where the mission may be changing.

Initialize / Start Scenario

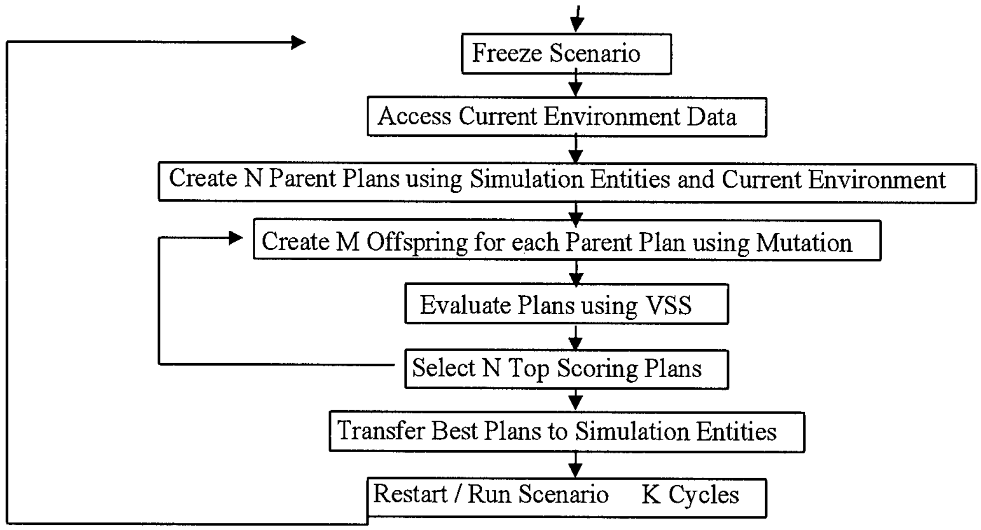


**Figure 1 Processing flow showing generation of behavioral plans using Evolutionary Programming and simulation model.**

By coupling a simulation model such as ModSAF (and eventually OneSAF) and Evolutionary Programming as shown in Figure 1, the set of possible CISs can be explored effectively and efficiently. Evaluation of the optimal sequence of CISs will be made in light of the current environment using the Valuated State Space Approach.

## PRODUCTS

1. Software in C that demonstrates the manner in which combat information sets can be evaluated and improved through the use of Evolutionary Programming.

2. Monthly progress reports and a Final Report covering this nine-month effort.

## MILESTONES.

1. Phase 1. Delivery of the Valuated State Space and normalizing function that portrays the mission to be accomplished generic form. This task will be completed within two months of initiation.

2. Phase 2. Software that demonstrates the manner in which combat information sets can be evaluated and improved through the use of Evolutionary Programming. This task will be completed within seven months of initiation.

## RISK/BENEFIT ANALYSIS

Evolutionary Programming has already been demonstrated for optimizing tank behavior in two-sided combat. This is a natural extension to evaluate combat instruction sets in comparison with evolved tactics. This demonstration may be of direct value and have immediate applications in the field.

**EXECUTABILITY**

A portion of this effort will take the form of additional tasking to be executed by Natural Selection, Inc. under their current contract with STRICOM, contract #N61339-95-C-0088. POC Susan Rodio, 407-384-3936.

*SIM-98-MTMC-02*

**PROJECT TITLE:** **Interactive Data/Information Visualization Tool**
(Pending Funding Availability)

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## EXECUTIVE SUMMARY

A Force Projection Modeling (FPM) user interface environment will enable users and decision makers to quickly explore, analyze, and manipulate information. The ability to evaluate and synthesize data quickly to identify and display the underlying problems and constraints is essential to improving projection planning and analysis through simulation. The proposed data/information visualization tool will provide an interactive method for exploring, analyzing, and visualizing information. Specifically, the project will develop frames/user interfaces from the current FPM Enhanced Logistics Intratheater Support Tool's (ELIST's) output graphs. These frames will provide the capability to drill down and synthesize data relating to force closure (e.g. cargo unloaded at port, cargo waiting to be unloaded, cargo arrived at the final destination, etc...). This development and modification effort will provide the Army modeling and simulation (M&S) community the capability to easily and accurately represent the underlying complex processes and data of all FPM models and simulations. Specifically, it will enable users to obtain, process, analyze, and display critical data quickly, identify problem areas, facilitate better informed decisions, and experimentation with new deployability concepts and technology.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

The purpose of this project proposal is to develop an interactive information visualization interface tool in support of the Force Projection planning and analysis.

A. Force Projection Modeling (FPM) is a suite of existing and new deployment modeling and simulation tools that planners and analysts can use to evaluate the force projection of units (personnel, equipment, and supplies) from their base or installation, to the port of embarkation (POE), through the port of debarkation (POD), to the tactical assembly area in theater. These tools model in detail the interaction of infrastructure and transport systems with the detailed transportability characteristics of the force and the throughput capability of ports and installations. The FPM suite includes full function graphical user interfaces that allow planners and analysts to access each individual modeling and simulation tool and an integration of several FPM simulations. It also includes a comprehensive set of graphs and reports that planners and analysts can use to fully evaluate simulation analyses. However, the analysts currently has to go through a series of unrelated graphs and reports to get to the kinds of information he or she may need to perform an analysis. For example, the Enhanced Logistics Intratheater Support Tool (ELIST) graphically displays closure information by "C" date, as well as tables of closure data. The problem is that there is no quick and easy way to determine why closure was not achieved on a specific "C" date and determine what items did not arrive on time. There is a great deal of time expended moving from various graphs and tables to find the problem or resource constraint(s); many times the knowledge of constraints resides with the ELIST expert familiar with how that particular scenario operates and has already expended the time to research where the constraints exist. The capability to drill down into the data to identify and display the underlying problems and constraints is essential to improving projection planning and analysis through simulation.

B. ELIST is a UNIX and object-based simulation that "flows" the TPFDD over a theater's transportation infrastructure. ELIST answers such questions as: Is the movement plan feasible? Will theater infrastructure support the plan? Will theater transportation assets support CINC required delivery dates? Who, what, and where are the constraints and bottlenecks? ELIST is used to provide critical information for deployment/redeployment planning. It evaluates alternative courses of action, selects routes that best suit objectives, identifies infrastructure that hinders deployment/redeployment objectives, and predicts closure to support future employment planning.

## TECHNICAL APPROACH

The approach to this project is to utilize a commercially available data visualization software, VISAGE, to develop "tailored" frames (user interface) capable of exploring, analyzing, and manipulating the data generated by ELIST. Its generic set of data navigation and manipulation tools and scripting language provide capabilities for developing customized applications for data-intensive domains, such as deployment. Specifically, the project will develop VISAGE frames from the current ELIST output graphs. These frames will provide the capability to drill down into the data relating to force closure (e.g. cargo unloaded at port, cargo waiting to be unloaded, cargo arrived at the final destination, etc...). The frames and user interface environment will capitalize on emerging data visualization technology to provide an intuitively understandable technique for communicating the state and results of ELIST. The user interface will allow analysts to obtain, process, and analyze critical data rapidly to identify problem areas in the simulated deployability process. The data visualization environment will also provide interoperability and compatibility with other Force Projection Modeling tools to:

- Analyze and merge redundant information into a single element.
- Conduct operator navigation through the data to identify trends, changes, and opportunities.
- Report status of underlying variables by clicking an object.
- Dynamically generate information visualizations.
- Perform basic information manipulation operations.
- Interact with data and applications.
- Fully integrate a presentation and briefing environment.
- Permit drag-and-drop manipulation of data elements at any level of granularity.
- Coordinate multiple displays by color highlighting a subset of units that occur close together on a map.
- Display information in a multi dimensional, visual format to enable rapid comprehension and insight.

## PRODUCTS

1. Interactive Data/Information visualization software integrated into the current version of ELIST.
2. Recommendations regarding future improvements and integration with other FPM models and simulations.

## MILESTONES

1. Initial planning and design. Completed by December 1997.
2. Initial conversion of selected ELIST output graphs to VISAGE. Completed by March 1998
3. Refinement/testing. Completed by June 1998.

## RISK/BENEFIT ANALYSIS

Without appropriate research, training, experimental design, and integration of individual analytical efforts relating to force projection, decision makers may be presented with incomplete and contradictory (difficult to understand) analytic results on which to base Force XXI and Army After Next (AAN) design decisions. This will result in an inadequate/poor assessment for development of Force Projection capabilities. These simulation efforts will assist in providing sound analytical underpinnings for Force XXI and AAN design decisions. These experiments/analyses will clarify how Army leadership, as well as other services, will have to plan for future force projection together and how force projection needs to be organized in an environment of reduced force structure but increased technological capability.

## EXECUTABILITY

This project proposal can be executed within one year of award.

*SIM-98-TRADOC-02*

**PROJECT NAME** **Multi-paradigm Command Decision Modeling Architecture**

**POINTS OF CONTACT**

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**EXECUTIVE SUMMARY**

Representing command and control decision-making in software is a critical and challenging task confronting the simulation community. As new simulations efforts such as WARSIM 2000, JSIMS, and JWARS are being developed, the M&S community is shifting towards larger-scale, higher-fidelity exercises in which there is an increased requirement for software implementations of intelligent command entities at higher-level military echelons in order to reduce the possible exponential growth in numbers of required role-players and unit controllers.

This effort will examine the technical issues and challenges associate with developing a multi-paradigm command decision modeling architecture spanning higher echelons of command. This effort will make use of the command agent architecture that was developed during the 2nd US/United Kingdom CDM Workshop hosted on behalf of the DUSA(OR) in December 1996. This project will examine the implementation of a Command Decision Modeling (CDM) prototype that employs a 2 phase approach of: (1) situation assessment [the staff's business] and (2) option assessment [the commander's art] to provide a course of action based on goals/objectives. The implementation of the prototype would consider extensive reuse of CFOR / CCSIL and a determination of the requirements would reveal the software modules that are most appropriate. A technical report will be delivered as well as a prototyped architecture.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

Representing command and control decision-making in software is a critical and challenging task confronting the simulation community. As new simulations efforts such as WARSIM 2000, JSIMS, and JWARS are being developed, the M&S community is shifting towards larger-scale, higher-fidelity exercises in which there is an increased requirement for software implementations of intelligent command entities at higher-level military echelons in order to reduce the possible exponential growth in numbers of required role-players and unit controllers.

## TECHNICAL APPROACH

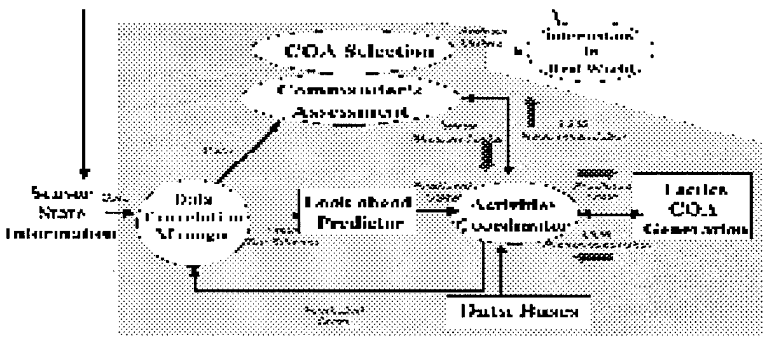
1. This project will examine the implementation of a Command Decision Modeling (CDM) prototype that employs a 2 phase approach of: (1) situation assessment and (2) option assessment to provide a course of action based on goals and objectives.

2. The two-phased approach is intended to model closely the military paradigm of a commander and his staff. The staff analyzes and interprets battlefield processes with specialized expert knowledge and present information to their commander as abstracted representations so that the commander does not have to process large amounts of information. Intelligent agent techniques applied in industry will be reviewed and utilized to model this relationship. Multiple advisor agents will perform situation assessment and provides estimates of the situation to a command agent which will choose course(s) of action based on its knowledge base and objectives.

3. This effort will make use of the command agent architecture that was developed during the 2d US/United Kingdom CDM Workshop hosted on behalf of the DUSA(OR) in December 1996. This architecture is pictured below.

4. The proposed architecture would consist of advisor agents implemented using an AI techniques appropriate for their knowledge source(s) and a command agent implemented using a knowledge based technique such as an expert system with a blackboard architecture. The interfaces between the advisor agents and the command agents will be generic to support the inclusion of additional advisor agents or the replacement of implemented advisors. An ability to interactively view/add/update goals and provide explanations for courses of action chosen will be developed.

5. The implementation of the prototype would consider extensive reuse of CFOR / CCSIL and a determination of the requirements would reveal the software modules that are most appropriate. This effort will also examine the architectural issues associated with brigade to battalion, battalion to company command issues for common applicability of a standard multi-paradigm command decision model.



**Proposed Command Decision Modeling Architecture**

6. A scenario will be chosen that includes both BLUFOR and OPFOR. The BLUFOR command agent will exhibit intelligent behavior while the OPFOR may exhibit reactive or common sense behavior. There may be a desire to have these behaviors be interchangeable. Behavior information on the entities in the proposed scenario will be obtained and a study of common sense vs. intelligent behavior in command agents will be conducted.

## PRODUCTS

This effort will examine the technical issues and challenges associate with developing a multi-paradigm command decision modeling architecture spanning higher echelons of command. A technical report will be delivered as well as a prototyped architecture.

## MILESTONES

| | Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Milestone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| CCSIL/CFOR Reuse Assessment | x | x | | | | | | | | | | |
| Detailed CDM Architecture Design | | x | x | x | | | | | | | | |
| Development of CDM Prototype | | | x | x | x | x | x | x | | | | |
| Multi-Paradigm CDM Prototype Analysis | | | | | | | x | x | x | x | | |
| Finalize Results and Deliver Report | | | | | | | | | | x | x | x |

**RISK/BENEFIT ANALYSIS**

A multi-paradigm command decision modeling architecture will be able to combine the strengths of several different solutions. A multi-paradigm approach will allow different command agents to operate on different sub-parts of a problem, thereby exploiting each paradigm's strength while avoiding its weaknesses.

**EXECUTABILITY**

| | |
|---|---|
| Contracts | 90% Existing support contracts with NSC and STRICOM. 100% of funds will be used for contract support. |
| In-House | 10% NSC, DCSINT, and ARI Team Oversight |

*SIM-98-ODCSINT-01*

**PROJECT TITLE:** **Multi-Resolution Modeling (MRM)**
(Pending Funding Availability)

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## EXECUTIVE SUMMARY

Multi-Resolution modeling is concerned with resolving conceptual and representational differences that arise from multiple levels of resolution in simulations that are joined. Even assuming valid simulation models, MRM is a challenging aspect of interoperability of simulations. Traditional MRM solutions employ aggregation and disaggregation; these techniques can cause temporal and mapping inconsistencies, chain disaggregation, network flooding and high transition latencies. This project researches an alternative approach employing "Multiple Resolution Entities (MREs)" to maintain internal consistency across multiple, concurrent levels of resolution. Consistent multi-resolution models for fire support will be built based on this alternative approach as a proof-of-concept.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

Multi-Resolution Modeling (MRM) is concerned with resolving conceptual and representational differences that arise from multiple levels of resolution in simulations that are joined for a common objective. Even assuming valid simulation models, MRM is a challenging aspect of interoperability of simulations that were designed and implemented independently. Traditional MRM solutions employ aggregation and disaggregation; these techniques can cause temporal and mapping inconsistencies, chain disaggregation, network flooding and high transition latencies. Existing solutions meant to solve some or all of these problems leave the central consistency problem unresolved.

## TECHNICAL APPROACH

1. An approach entitled "Multi-Resolution Entities (MREs)" proposed by Dr. Paul Reynolds at the University of Virginia will be evaluated as a means to maintain consistency across multiple, concurrent representations at varying levels of resolution. Each MRE either maintains state information at all desired levels of resolution or furnishes information at a requested level in a timely manner. Simulation of the MRE entails consistently reflecting the effects of interactions at all levels. An MRE interacts at multiple levels of resolution concurrently by internally enforcing logical consistency among corresponding attributes at different levels of resolution.

2. In order to model entity behavior at multiple levels of resolution, relationships among

attributes must be captured. These relationships can be modeled by a directed, weighted graph wherein the nodes represent attributes and the edges between the nodes represent relationships.

3. Consistent multi-resolution models for fire support will be built using the MRE approach. UVA will assume that valid models of fire support at the various levels of resolution pre-exist. We expect to use Eagle and ModSAF as the basis for these models. The Federate Object Models (FOMs) for Eagle and ModSAF specify the attributes of entities within these simulations, and the Simulation Object Models (SOMs) specify the interactions that affect various entities. UVA will modify the Eagle and ModSAF FOMs and SOMs for fire support to construct simple fire support entities. UVA will ensure that the simplifications they make retain the essential characteristics of real fire support models so that in the future, extending these consistency maintenance techniques to real models becomes simplified. Once the models have been established, UVA will incorporate consistency maintenance within the multiple levels of resolution.

4. UVA will construct MREs and attribute dependency graphs for fire support with a view to incorporating consistency, measuring the quality of consistency and studying the costs associated with consistency maintenance.

## PRODUCTS

The ability to maintain consistency between multiple levels of resolution for these entities, the quality of the consistency achieved, and the costs associated with maintaining the consistency will be evaluated. Results will be detailed in a technical report with appendices containing the constructed models.

## MILESTONES

| | |
|---|---|
| Contract award. | 1 month |
| Obtain model FOMs, SOMs. | 1 month |
| Develop fire support entities. | 2 months |
| Construct attribute dependency graphs. | 2 months |
| Incorporate consistency maintenance. | 2 months |
| Measure quality of consistency maintenance. | 2 months |
| Assess costs. | 1 month |
| Write report. | 1 month |

**RISK/BENEFIT ANALYSIS**

Consistency maintenance is a hard problem which to date has not been resolved satisfactorily. This work will demonstrate new and needed approaches for making simulations at different levels of resolution interoperable. If successful, it will have widespread benefit for the DoD simulation community by providing an inexpensive, reusable and valid approach to the interoperability of simulations at varying levels of resolution. There are no technical hurdles to the creation of MREs for fire support and thus the risks associated with this project are negligible.

**EXECUTABILITY**

This project can be executed through an existing contract between the National Ground Intelligence Center and the University of Virginia.

**_SIM-98- ODCSINT-01_**

**PROJECT TITLE** **Mutual Enhancement of the Virtual Environment Database Server and the Soil Response Modeling Effort**

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**EXECUTIVE SUMMARY**

As part of the on-going development of the Virtual Proving Ground, Aberdeen Test Center (ATC) has developed a Virtual Environment Database Server (VEDS). The VEDS consists of a geographically accurate, and visually impressive, synthetic environment based on actual test courses at ATC. The Waterways Experiment Station (WES) has introduced a theoretical representation of high resolution soil-traction element interaction based on mobility-related environmental parameters. The opportunity now exists to fuse certain physical parameters used in the WES Soil Response Modeling (SRM) effort with existing VEDS parameters, for use in modeling and simulation of high-resolution vehicle-terrain interaction. This process will represent a major step in the development of the Virtual Proving Ground and simulation-based acquisition, by mutually enhancing the WES physics-based soil response algorithms and the ATC data based empirical models.

**BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM**

1. As part of Virtual Proving Ground (VPG), the U.S. Army Aberdeen Test Center (ATC) at Aberdeen Proving Ground (APG), Maryland has successfully implemented a Virtual Environment Database Server (VEDS). The VEDS contains a complete characterization of three local vehicle test courses. The synthetic environment of the VEDS contains three-dimensional geographical points which were measured every one-third of a meter, and are accurate to within 0.1 meter. Output from the VEDS can be combined with other models, such as TARDEC's Hull Motion Model, the University of Iowa's National Advanced Driving Simulator, and STRICOM's Close Combat Tactical Trainer, to simulate the motion of a virtual vehicle when driven over a virtual test course. It can be used to predict dynamics of the vehicle function, such as roll, pitch, and yaw. When the test run is displayed on the VEDS system it is graphically accurate. However, other mobility-related physical parameters of the test courses (e.g. soil type, moisture content, micro-roughness) have yet to be incorporated into the VEDS.

2. Elsewhere, physical models of soil-traction element interaction have been developed. The Waterways Experiment Station (WES) has introduced a physics-based

representation of high resolution soil-traction element interaction, based on mobility-related environmental parameters developed through their Soil Response Modeling (SRM) effort. This effort models soil characteristics of an area, and then predicts soil - traction element interactions, such as slip and shear, as wheeled and tracked vehicles traverse the particular surface. WES has obtained promising results from their algorithms to date. The existing model applies to straight line vehicle motion. Additional empirical data is needed for further validation and expansion; development continues in cooperation with the Industry/University Cooperative Research Center (I/UCRC) for Virtual Proving Ground Simulation.

3. Aberdeen Test Center has ongoing and planned testing of several military vehicles. Thus, the opportunity exists to include in these tests the instrumentation necessary to obtain the required data for the SRM validation by WES. An ATC/WES cooperative venture is proposed, to characterize and fuse certain physical parameters used in the WES Soil Response Modeling (SRM) effort with existing VEDS parameters for modeling and simulation of high resolution vehicle-terrain interaction. WES will identify mobility-related parameters and work with ATC to characterize the virtual environment in terms of soil - traction element response. Procedures will be developed to fuse this information with VEDS for correlation of the virtual environment and the physics of soil-traction element interaction. ATC will obtain data for the SRM algorithm validation and expansion and inclusion in VEDS. This process will represent a major step in the development of the Virtual Proving Ground and simulation based acquisition initiatives, ascribing physics-based models to the scenes.

## TECHNICAL APPROACH

1. Mobility-related physical parameters of the test courses will be characterized at ATC by conducting experiments and analyzing data for the SRM. Sections of Munson, Churchville, and Perryman courses, as well as soft-soil sites will be analyzed to determine 1) classification, 2) bearing capacity, 3) moisture content, 4) remold index, 5) motion resistance, 6) micro roughness , and 7) any other identified pertinent physical parameters needed for soil - traction element interaction modeling. The cone index of the soil will be measured using cone penetrometers at regular intervals along the length of the course. If homogeneity is found, extrapolation will be made of other areas of the course.

2. ATC will design experiments and instrument vehicles to measure the torque at the wheels, vehicle speed, wheel speed, throttle position, and drawbar pull or tractive effort while traversing test courses. Tracked vehicles available at ATC will include the AAAV, AMTV, C2V, DEUCE, Grizzly, HAB, M1A2, M2A3, and M7A1 BFIST. Wheeled vehicles include the LAV, FMTV, HMMWV, and PLS. WES and

3. Cone index measurements and surface roughness profiles will be taken between runs to analyze soil compaction and micro-roughness changes due to vehicle passage.

4. WES will assess measured and computed soil-traction element performance for use in

evaluating and enhancing SRM algorithms. Parameters needed to model steering and lateral forces will be investigated.

5. A means will be developed to couple mobility-related parameters with VEDS for correlation of the virtual environment and the physics of soil-traction element interaction. ATC and WES will integrate appropriate SRM algorithms into the VEDS software routines and relate test course parameters and pertinent mobility-related factors with the existing VEDS.

6. The fused algorithms which incorporate VEDS visual and mobility-related parameters will be made available to other activities to interact with various vehicle models.

## PRODUCTS

1. A VEDS with pertinent physical parameters related to soil - traction interaction embedded in it.

2. A further validated SRM related to off-road standard test courses.

3. A comprehensive collection of vehicle data applicable to soil interaction, etc.

4. Improved capability to "drive" vehicles over virtual test courses and evaluate performance.

5. Validated algorithms for applications such as TARDEC's Hull Motion Model, TACOM's vehicle dynamics modeling efforts, University of Iowa's National Advanced Driving Simulator(part of the I/UCRC), STRICOM's tactical trainers, and for more realistic training and requirements generation exercises and operations planning.

## MILESTONES

| Task | FY98 |
|---|---|
| | ONDJFMAMJJAS |
| Characterization survey of APG test courses. | ^ |
| Databasing of soil and related test course properties. | --^ |
| Collection of data from vehicle tests at ATC. | ------^ |
| Model validation and expansion by WES. | -------^ |
| Linking appropriate SRM algorithms, data, and VEDS routines | -------^ |

## RISK/BENEFIT ANALYSIS

1. The technical risks involved with this project are minimal. Because of the developmental uncertainties associated with the expansion of the SRM, success may not be achieved in the time frame given. The risk of not funding this project includes, at a minimum, a delay in the accomplishment of the mandated requirement to conduct acquisition by means of virtual simulation.

2. The benefits to the modeling and simulation efforts, as outlined above, are substantial. The integration of VEDS and SRM will advance *research and development* of the VPG concept beyond geography and graphics, by incorporating physical parameters into the VPG. It will also represent another step towards streamlining the *acquisition* process by allowing vehicles to be tested in a synthetic environment before they are physically built and tested. It will also help to define simulation based acquisition *requirements*. Furthermore, it will have great benefits to soldier *training* by helping to make the response of man-in-the-loop training simulators more realistic. Finally, the validation and expansion of the SRM will have wide applicability to *military operations* and *mission planning*, for instance, by improving the prediction of mobility capability through various terrains.

**EXECUTABILITY**

This project will be a mutual and cooperative effort between ATC and WES. The necessary soil and vehicle data will be collected at ATC. Because this would involve leveraging tests already being conducted, the costs associated with obtaining these data would be minimal, estimated to be only $25K. WES will validate and expand the SRM model. The I/UCRC has already dedicated $100K to the SRM effort. ATC and WES will work together to enable the improved VEDS and SRM to interact with vehicle models. This is estimated to cost $50K. These programs will then be available to others in the modeling and simulation community, such as TARDEC, TACOM, STRICOM, and the University of Iowa. A breakdown of the funding utilization is presented in the following table.

*SIM-98-MTMC-01*

**PROJECT TITLE** **Port Simulation Model (PORTSIM) 3-dimensional Visualization System**

**POINT OF CONTACT**

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**EXECUTIVE SUMMARY**

The purpose of this simulation project is to develop and incorporate a 3-Dimensional (3D) visualization system for the constructive Port Simulation model, PORTSIM. PORTSIM is a time-stepped, discrete event, stochastic simulation of port operations. Incorporating 3D visualization into PORTSIM will increase the capabilities of the simulation. Using 3D, transportation planners can quickly visualize bottle necks located at a port of embarkation or debarkation, better determine the types and kinds of material handling equipment needed, visualize staging areas, and accomplish other planning associated with moving forces through ports. PORTSIM 3D will also become the cornerstone of the Virtual Sealift Emergency Deployment Readiness Exercise (SEDRE). The Virtual SEDRE will simulate and visualize the deployment activities that occur at specific installations and ports and supplement and complement live SEDREs and deployments. The nature of PORTSIM's 3D visualization system is an ambitious use of emerging graphics, animation, and virtual reality technology to provide an intuitively understandable technique for communicating the state and results of PORTSIM. The visualization goal for PORTSIM is to create immersive environments using GIS based infrastructure data, 2D animation, and 3D virtual environments. Initially, the system will display in 3D the output of a PORTSIM simulation run. However, the goal is for the 3D virtual environments to run in conjunction with a PORTSIM run using the High Level Architecture (HLA). As part of this project, Argonne National Lab (PORTSIM developer) will investigate the use of HLA in the visualization system.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. The purpose of this simulation project is to develop and incorporate a 3-Dimensional (3D) visualization system for the constructive Port Simulation model, PORTSIM.

2. This initiative supports the efforts of the Military Traffic Management Command (MTMC) and the U.S. Army Transportation Center among others. It will provide a realistic 3D visualization system to support port planning, analysis, training, and operations. PORTSIM is a time-stepped, discrete event, stochastic simulation of port operations. The model contains a reference access to port, unit equipment, and strategic-sealift databases, providing not only textural data but also reference graphics. It currently simulates and animates in 2D port throughput activities, including rail offload, equipment staging, and ship berthing. PORTSIM determines a port's throughput capability, identifies any systems, or infrastructure constraints, and provides port specific force clearance profiles. The user can also measure the effects of Logistics-Over-the-Shore (LOTS) on port operations. A number of commercial, open source, and classified port references are integrated for easy use and access.

3. PORTSIM is an integral part of the MTMC Transportation Engineering Agency's (MTMCTEA's) Force Projection Modeling system. It is also the cornerstone of the Virtual Sealift Emergency Deployment Readiness Exercise (SEDRE). With the reduction in the numbers of SEDREs performed in a year, the deployment community needs alternative methods to train and prepare units for actual deployments. The Virtual SEDRE will simulate and visualize the deployment activities that occur at specific installations and ports and supplement and complement live SEDREs and deployments. The Virtual SEDRE will allow deploying units, transportation movement officers, port commanders, and transporters, in general, to exercise deployment plans, rehearse missions, and visualize the defense transportation system in simulation, thus improving upon actual deployments and exercises.

4. Incorporating 3D visualization into PORTSIM will increase the capabilities of the simulation. Using the 3D aspects of PORTSIM, transportation planners can quickly visualize bottle necks located at a port of embarkation or debarkation, better determine the types and kinds of material handling equipment needed, visualize staging areas, and accomplish other planning associated with moving forces through ports. In effect, a 3D PORTSIM satisfies the age old saying, "that a picture is worth a thousand words."

## TECHNICAL APPROACH

1. This project will utilize both government (PORTSIM) and commercial off the shelf modeling and visualization software. The nature of PORTSIM's 3D visualization system is an ambitious use of emerging graphics, animation, and virtual reality technology to provide an intuitively understandable technique for communicating the state and results of PORTSIM. The visualization goal for PORTSIM is to create

immersive environments using GIS based infrastructure data, 2D animation, and 3D virtual environments. The system will use the underlying analyst defined routing scenarios constructed with tools contained in PORTSIM. Vehicle templates traversing these routes will carry item level data as derived from the MTMCTEA TARGET/ECMDF databases. Ship data will be read from the JFAST Ships database. The Operation of these components within one homogenous structure will use the PORTSIM simulation as its engine or driver. At present, development of these technologies are platform specific and are being created using proprietary developmental software. The future trend will be to migrate this development onto a more open and platform independent format such as JAVA.

2. MTMCTEA has already produced much of the GIS and 2D animation data, and some 3D data of equipment and specific seaports for use in the visualization system. However, funding from this project will be used by MTMCTEA to refine/complete its existing 3D object library and complete a virtual environment of a specific seaport.

3. Argonne National Lab (ANL) will define and build the interface between PORTSIM and the virtual environments. Initially, the visualization system will animate the results of a PORTSIM simulation run. However, the goal is for the virtual environments (application initiated databases) to run in conjunction with a PORTSIM run using the High Level Architecture (HLA). As part of this project, ANL will investigate the use of HLA (along with another ongoing effort to make PORTSIM HLA compliant) in the visualization system.

**PRODUCTS**

An initial and functional 3D visualization capability for PORTSIM capable of displaying the results of a PORTSIM simulation run that the 7th Transportation Group, DPMO (FPCO) Center of Excellence for Force Projection Simulation Center, U.S. Army Transportation Center Deployment Training Facility, Military Traffic Management Command (MTMC) sub-commands, and CINC staffs can use to support ongoing efforts.

**MILESTONES**

1. Develop 3D virtual environments for a specific seaport (Garden City Terminal-Savannah, GA) - December 1997.
2. Design/build/test interface b/w GIS, 2D animation, and 3D visualization - April 1998.
3. PORTSIM results using 3D visualization system - July 1998.
4. Design/build HLA interfaces to 3D visualization system - Sep 1998.
5. Test/Refine HLA interfaces - December 1998.
6. Build PORTSIM visualization graphical user interface (GUI). Completed by March 1999.

**RISK/BENEFIT ANALYSIS**

There is little risk of technical failure in this project. Without appropriate research, training, experimental design, and integration of individual analytical efforts relating to force projection, decision makers may be presented with inaccurate and contradictory analytic results on which to base Force XXI and Army After Next (AAN) design decisions. This will result in an inadequate/poor assessment for development of Force Projection capabilities. These simulation efforts will assist in providing sound analytical underpinnings for Force XXI and AAN design decisions. These experiments will clarify how Army leadership, as well as other services, will have to plan for future force projection together and how force projection needs to be organized in an environment of reduced force structure but increased technological capability.

**EXECUTABILITY**

The primary developers for this capability will be MTMCTEA and Argonne National Lab (ANL-PORTSIM developer). A contract is already in place between MTMCTEA and ANL for PORTSIM development. The contract can be executed immediately after contract award.

*SIM-98-AMC-02*

**PROJECT TITLE:** **Simulation Support Environments (SSE) for Army Modeling and Simulation (M&S)(SSEAMS)**

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## EXECUTIVE SUMMARY

An ongoing effort at DoD is aimed at establishing a tri-service standard SSE. The objective of this effort is to allow subject matter experts within the services to more easily develop and use M&S which take advantage of up to date hardware and software technologies. AMSAA's current SIMTECH project is one of a small group of pilot projects which are providing information in support of this DoD effort.

In our current project we are evaluating the capability of the Joint Modeling and Simulation System (JMASS) to serve as a standard SSE. JMASS is the Air Force Developed SSE which inspired the DoD effort in the first place. This is a proposal for the continuation and expansion of the current project to provide additional information on Army requirements for a standard SSE and the ability of existing systems to meet those requirements.

Under this proposal, we will continue our work on terrain representation and will also explore the issues of DIS compatibility and extensibility. (i.e. the ability to incorporate existing software tools into the SSE environment) In this second year of the project, we will look not only at JMASS, but also at TACTICS, another SSE which has been developed by TACOM.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. In recent years, a number organizations have begun to explore the idea of having an environment to support the full range of M&S activities, in much the same way that office automation suites support the full range of office automation activities. Two examples of such systems are JMASS, which has been developed by the Air Force, and TACTICS, which has been developed by TACOM.

2. There is an ongoing effort, which also goes by the name of JMASS, to establish a standard SSE for the DoD community. AMSAA participated in a Technical Review

Panel which made a preliminary evaluation of JMASS, TACTICS, and a third system, SAMSON, which is under development at Los Alamos National Labs. The TRP concluded that a standard SSE was a desirable goal, and that the desired system would combine characteristics of all three candidate systems. JMASS was seen to be more mature with a more complete set of tools. TACTICS appeared to have better architecture which would provide a better interface to COTS products and greater flexibility to M&S developers. SAMSON, though less mature than the other systems was seen as an source of lessons learned for real time, hardware-in-the-loop applications. A number of pilot projects are now being conducted. These are to confirm and refine the conclusions of the TRP and to explore additional issues regarding standard SSE's. These Pilot projects will provide input in support of a decision on whether to establish a standard SSE within DoD and if so, what form it should take.

3. Some of the potential benefits of such a system include: simplified development and modification of M&S through the use of graphical user interfaces and automated code development tools; easier and cheaper development of M&S which accurately represent complex systems and processes through libraries of reusable objects which can run in a distributed processing environment; greater interoperability within and between domains because of standards and reusable objects; and a state-of-the-art working environments for M&S developers and users.

4. AMSAA's current SIMTECH project, Army M&S in the JMASS Environment (AMJE) is one of the JMASS pilot projects. This is a proposal for a continuation of that project to explore some issues in greater depth and to look at additional issues of interest to the Army. The current project is looking at the quality of support provided by the Air Force JMASS for a wide range of M&S activities. The ability of JMASS to support M&S at various levels of detail and its ability to support terrain representation are two areas of particular interest.

5. In the second year of the project, we will evaluate the flexibility of JMASS and its ability to support different levels of detail by developing a more detailed terrain representation. This will replace the Incursion statistical terrain model with a digitized terrain representation. We will also work with TACOM to acquire a TACTICS capability at AMSAA and test the TRP conclusions regarding the TACTICS architecture. We will investigate the ability of both JMASS and TACTICS to support DIS compatible M&S (Providing insight to their ability to support HLA compatible M&S in the future.) and to interface with and take advantage of existing graphics and analysis tools. The results of these evaluations will influence the decisions on whether we will have a tri-service SSE and, if so, what form it should take.

6. A tri-service standard SSE is intended to advance all five of the AR 5-11 program goals by providing standards and tools to improve M&S development and modification techniques; establishing a library of V&V'd models representing complex processes;

encouraging reuse to development costs; providing a standard architecture to increase interoperability among and between domains; and providing a user friendly, state of the art environment for M&S personnel within DoD. Through this project we are helping to ensure that the ongoing effort to establish a standard SSE will lead to a viable system which meets Army M&S needs.

## TECHNICAL APPROACH

1. We will continue the technical approach taken during the first year of this project. That is, we will evaluate the support JMASS and TACTICS provide for various M&S activities by using those SSE's to carry out those activities. With JMASS we have established a JMASS capability at AMSAA and are developing a new version of the Incursion model in the JMASS environment. Many of the objects being developed for this purpose implement standard army algorithms. In the second year we will upgrade to JMASS 3.2 when it becomes available, testing the upward compatibility. We will complete the development of digitized terrain model. This is a necessary step before JMASS can be used to (a)upgrade Incursion (from one on one to few on few capability) and (b) add DIS compatibility.

2. We will work with TACOM to establish a TACTICS capability at AMSAA and to uplift our C++ version of the Incursion model into the TACTICS environment.

3. Using both environments we will carry out the investigation of DIS compatibility and the ability to interface with graphics and analysis tools. For the DIS compatibility effort, we will develop a capability to interoperate with the ModSAF suite at AMSAA.

## MILESTONES

| | |
|---|---|
| Oct 97 | Upgrade to JMASS 3.2 |
| | Establish TACTICS capability |
| Dec 97 | Detailed terrain model in JMASS version |
| Jan 98 | TACTICS version operational (including detailed terrain model) |
| Mar 98 | Interim results input to DoD decision process |
| May 98 | DIS compatibility with both systems |
| Jul 98 | Tool interfaces established for systems |
| Sep 98 | Final Report |

## RISK/BENEFIT ANALYSIS

1. Benefits:

   A. Input into DoD JMASS decision process, providing on Army issues

   B. Provide sets of objects which implement standard Army algorithms in the JMASS and TACTICS environments

C. Object oriented Incursion with enhanced capabilities

D. Lessons learned and recommendations on future use of a SSE within the Army and DoD

2. Risks:

A. Primary risk is the ability to complete this ambitious set of objectives with the two work years allotted. Activities will be prioritized and carried out so as to provide maximum benefit to Army and DoD decision makers.

B. Achieving consistency of representation of time, terrain etc. with other models in the DIS environment.

**EXECUTABILITY**

This project will be executed by AMSAA. We will continue to work with JMASS SPO on JMASS upgrades, representation of terrain within JMASS, and identification of problems detected. We will establish a similar working relationship with TACOM. PM DIS will provide consultation on DIS compatibility in general and ModSAF in particular.

*SIM-98-OPTEC-01*

**PROJECT TITLE:** **Simulation Testing Operations Rehearsal Model - Visualization System (STORM-VS)**

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## EXECUTIVE SUMMARY

This project will research and design a system to view/visualize the Simulation Testing Operations Rehearsal Model (STORM) synthetic battlefield before, during, and after development or operational testing. STORM is an initiative to provide a synthetic battlefield environment to prepare for and conduct brigade and below Command, Control, Communication, Computers and Intelligence (C4I) and Tactical Internet (TI) Operational Test and Evaluation (OT&E). The STORM simulated environment will range from dismounted soldiers and individual vehicles through theater and national C4I systems/assets. Hardware and software interfaces will link the live brigade and below C4I systems under test, via tactical or realistic communication models, with brigade and below entity based simulations. Existing simulations and test support tools will be used to the maximum extent possible. STORM will provide scenario generation, database population, C4I stimulation, and test visualization capabilities.

The STORM Visualization System (STORM-VS) will aid analysts during test preparation to generate optimum scenarios, populate system-under-test and simulation databases, rapidly evaluate pre-test rehearsals, and develop/train tactics techniques and procedures. During test execution, the system will allow rapid analysis and feedback in support of test control. During post-test analysis, the system will aid analysts to visualize the test, understand the test data, and examine "what if" excursions.

The STORM-VS project will deliver a report that documents a detailed design and the supporting research.

## BACKGROUND

Force XXI Battle Command Brigade and Below (FBCB2) OT&E, requires a robust, real-time, technically correct, and operationally realistic flow of digital information to the "live" systems under test and evaluation. A full heavy brigade, including a threat realistic opposing force, in the field along with all other systems or units that would provide digitized data to the brigade is required for adequate OT&E. The cost of deploying this size force for testing is not practical with current fiscal and OPTEMPO constraints. This severely limits the ability to fully stress brigade and below C4I operations with realistic information. An engineering study to examine the technical issues for developing a simulation/stimulation environment that uses Entity Based Models (EBMs) to replicate entities and C4I systems that are not present in the live field test was completed in early FY97. Based on the study, a developmental effort entitled STORM has been initiated to support FBCB2 operational testing (Limited User Test - 3rd Qtr FY98, Force Development Test and Evaluation - 3rd Qtr FY99, Initial Operational Test and Evaluation - 1st Qtr FY00). The study recommends that a visualization capability be leveraged from existing After Action Review (AAR) and entity level visualization systems. The overall development of STORM is an OPTEC, TECOM, TRAC, and STRICOM combined initiative.

## TECHNICAL APPROACH

The STORM-VS project will leverage existing expertise and tools. Commercial-off-the-shelf and government owned visualization and AAR tools will be used to the maximum extent possible. The project will have three phases:

- Detailed visualization requirements for pre-test, during-test, and post-test will be identified.
- Existing visualization systems and tools will be identified and investigated to ascertain their potential contribution for satisfying the requirements.
- A detailed design for a visualization system that leverages existing systems and tools and satisfies the requirements will be proposed.

## PRODUCTS

The deliverable will be a detailed report that documents the proposed design and supporting research.

## MILESTONES

| | |
|---|---|
| Project Approval | 1 October 1997 |
| Funds Received | 15 October 1997 |
| Requirements Identified | 15 January 1998 |
| Existing Systems/Tools Identified | 15 March 1998 |
| Proposed Design Drafted | 15 May 1998 |
| Proposed Design Finalized | 15 June 1998 |
| Final Report | 15 July 1998 |

## RISK/BENEFIT ANALYSIS

This project will be the basis for development of a standard visualization tool to support Army Battle Command System OT&Es. The project supports the Army Model and Simulation Master Plan Visualization Standards Category by defining and designing a tool "to provide a seamless vision of the battlespace by incorporating and integrating the environment, entities and their psychologies across virtual, constructive and live simulations". Visualization of the STORM synthetic battlefield will significantly enhance the conduct of test operations, as well as aid the analysts and evaluators in interpreting the results. The Visualization System is essential for STORM's future use as a tactical C4I training system.

**EXECUTABILITY**

TEXCOM in-house efforts to provide oversight and guidance will account for approximately five percent of the project. Ninety five percent of the project will be executed by the Simulation, Training and Instrumentation Command (STRICOM) under the Advanced Distributed Simulation Technology II (ADST II) program by the Unilateral Delivery Order (UDO) contractor.

*SIM-98-SMDC-01*

**PROJECT TITLE:** **Tactical Simulation Interface Unit (TSIU) Army Battle Command System (ABCS) Compatibility**

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## EXECUTIVE SUMMARY

The TSIU is being developed by the US Army Space and Missile Defense Command (SMDC) to serve as a simulation (Distributed Interactive Simulations Protocol Data Units and Command and Control Simulation Interface Language) to C4I tactical protocol translator. This project will evaluate, test, and implement within the TSIU, a Defense Interface Infrastructure Common Operating Environment (DII COE) compliant system. As future ABCS and other hardware/software systems migrate to DII COE compliance, it will be necessary that the TSIU maintain a parallel software development path. This task will allow for the TSIU to become a "client/server", two way interface between simulation and tactical protocols. This product will provide a leave behind, user friendly government owned system, capable of testing ARMY BATTLE COMMAND SYSTEM (ABCS) hardware and training users on their "go to war" ABCS hardware.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

The Commanding General, SMDC, as the Army's proponent for Theater Missile Defense developed a Tactical Operation Center system (Force Projection Tactical Operation Center - FPTOC) capable of synchronizing the four pillars of Theater Missile Defense - attack operations, active defense, passive defense, and battle management/command, control, communications, computers, and intelligence. The Missile Defense Battle Integration Center was levied the requirement to develop a simulation and interface environment capable of testing and training the tactical hardware resident in the FPTOC. As a result, the USASMDC developed the TSIU. The TSIU is being modified/developed by the US Army SMDC (Space and Missile Defense Battle Lab)as a means of stimulating "real world" C4I systems in the areas of space, national missile defense, and theater missile defense. To date, the TSIU computer hardware and software provides the interface between the Army Theater Missile Defense Element Tactical Operations Center, formally FPTOC, and simulations executing on the Distributed Interactive Simulation (DIS) network and Command and Control Simulation Interface Language (CCSIL). The TSIU is the means by which the ATMDE accesses the virtual simulation battlefield for training exercises and scenarios. The TSIU acts as a radio, receiving two way message traffic from the simulation environment and providing tactical messages to specific tactical systems within the

ATMDE. The TSIU generates FAAD Data Link (FDL), United States Message Text Format (USMTF), Tactical Information Broadcast Service (TIBS), Tactical and Related Applications (TRAP), TADIL-B, and Variable Message Format (VMF) tactical messages from a set of unclassified predefined pseudo-tactical messages which it receives via a radio Signal Protocol Data Unit (PDUs) and CCSIL data units. The tactical messages are sent to the C4I work stations within the ATMDE via a Local Area Network (LAN) and/or Serial links. The TSIU is written in Ada and C++ an operates on the Solaris 2.5 operating system. The TSIU software is resident on a Sun Ultra workstation. Tactical message formats and processing software are contained on removable magnetic media (hard drive) and may be either classified or unclassified, depending upon the classification of the tactical message formats. Many of these C4I tactical systems are being modified as part of the Army Battle Command System program in support of the digitized Army. These systems will work in a Common Operating Environment, similar in fashion to a "client server" relationship. As these systems are fielded, it will be necessary to provide a virtual simulation training environment necessary to train the users on their "go to war" systems. To date, no interface exist that will meet the demands of the operating environment that is being developed within the ABCS tactical hardware, and provide the warfighters a mechanism that allows the use of simulations to support training of the users on these COE compliant systems.

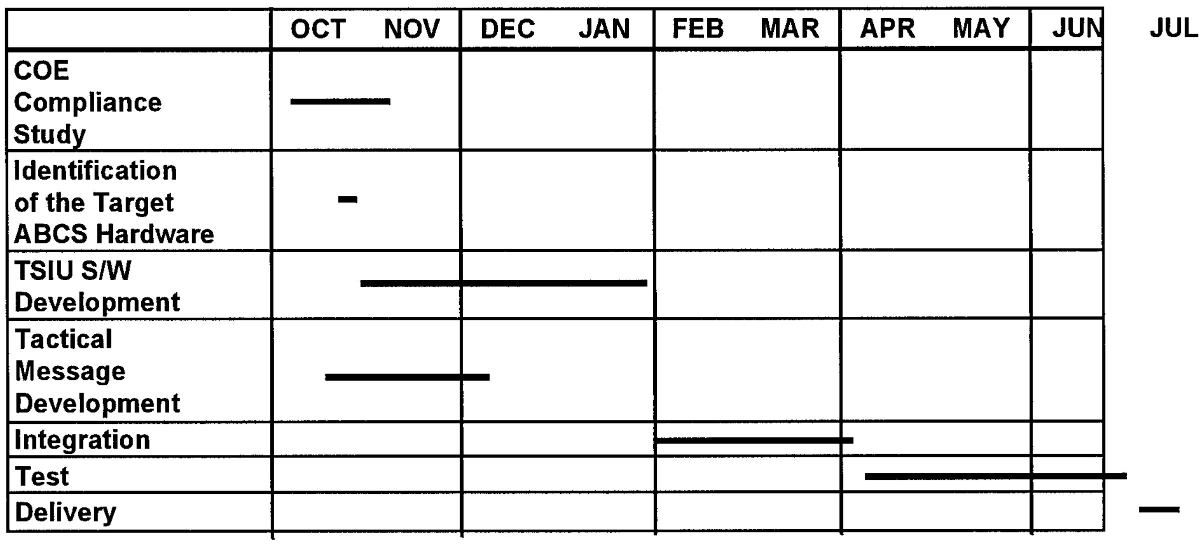
## TECHNICAL APPROACH

This project uses the existing TSIU baseline maintained under configuration management by SSDC. The existing software will be modified to allow the TSIU to integrate into the tactical network under the COE client-server paradigm and be responsive to information requests from the tactical $C^4I$ systems, specifically, the Maneuver Control System-Baseline. This effort will introduce five additional USMTF tactical protocols. Current USMTF capability includes the following USMTF tactical protocol formats: (1) S507L Resources, (2) S309 En Interop, (3) C-488 NBC-1, (4) C-447 NBC-2, and (5) C-121 TACELINT. It will functionally perform similarly to its current role of providing information flow between the simulation environment and the tactical world. A requirements matrix of capabilities which correlates existing and planned SSDC funded implementation with capabilities identified for COE compliance will be developed and a priority assigned for each requirement. Developed requirements will be integrated into the baseline using existing configuration management procedures.

## PRODUCTS

Project completion will provide a SSDC configuration managed, government owned, leave behind system capable of supporting a two-way interface between the virtual simulation environment and the tactical $C^4I$ workstations. A graphical user interface and training package is currently funded by SSDC for TSIU current functionality; this package would include any functionality added to the baseline and will support the use of the TSIU by third parties as a leave behind capability.

## MILESTONES




## RISK/BENEFIT ANALYSIS

Technical risks lie principally in the identification of simulations and simulators that are capable of the information required to support a lower echelon training environment. Many training exercises use the Corps Battle Simulation (CBS) as the simulation driver. The challenges with coupling the TSIU with CBS lie in the data that is available in the CBS Master Interface and CBS's capability to accept inputs from the TSIU. Augmentation of CBS with a higher fidelity simulation may be required for CBS driven exercises. A potential solution to this would be to couple the TSIU to the Modular, Semi-Automated Forces Model (ModSAF) or follow on, OneSAF. ModSAF uses the CCSIL protocol and will be linked to the TSIU as part of the Army Experiment 4. Another potential source would be to couple the TSIU to the Command and Control Tactical Trainer (CCTT) and the CCTTSAF, both of which will be used in the training of the digitized Brigade. Delivery of this leave behind capability will provide the warfighter an economical, and in some cases the only feasible, means of training and mission rehearsal within a virtual combat environment.

## EXECUTABILITY

The developer of the TSIU, Coleman Research Corporation (CRC), will perform 100% of this task. OPA funds will be used to procure a transportable Sun Ultra, necessary for field use, to host the TSIU software.

*SIM-98-AMC-04*

**PROJECT TITLE:** **Thermal Sensor Simulation in Near-Real-Time (SWISS)**
(Pending Funding Availability)

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**EXECUTIVE SUMMARY**

Building on our FY97 results in creating a ray-traced synthetic image generator capable of operating in near-real-time on very complex and highly detailed scenes in the visual band, we propose to extend this synthetic image generation capability into the multi-spectral domain, by supplementing the visual capabilities with a fully multi-spectral architecture, and with specific modules for thermal image generation across the 1 to 12 micron band. We will make maximum use of the SWOE results as our starting point.

The primary goal is to produce real-time imagery for the development and testing of missile automatic target recognition (ATR) systems incorporating second generation FLIR. This work also addresses one of the pressing needs of the Distributed Interactive Simulation (DIS) community by providing the ability to add a physically accurate high-resolution multispectral signature generation node to a distributed simulation when new sensor technology needs to be explored.

This proposal seeks support for the research and development necessary leading to an integrated real-time optical and thermal image generation capability using the ray-tracing technique. We request support for manpower and travel and the purchase of a single workstation; $14M of hardware resources are provided through the DoD HPC Shared Resource Center in Aberdeen Maryland.

This is a joint project with U. S. Army CECOM Night Vision and Electronic Sensors Directorate. Current BRL-CAD software is in wide use for signature generation within the U.S. Defense and Intelligence communities. BRL-CAD has a broad user-base of over 1800 institutions, with heavy use for medical and civil applications. The dual-use leverage factor for this work is substantial, as well as offering particular application to the T&E community.

**BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM**

1. The U.S. Army Ballistic Research Laboratory Computer Aided Design Package (BRL-CAD) is the U. S. Army's third generation solid modeling system. It is government-owned software written entirely in the C programming language. BRL-CAD includes a fully parallelized ray-tracing library and support for fault-tolerant network distributed ray-tracing. A collection of combinatorial solid geometric (CSG) models of hundreds of foreign and domestic military vehicles already exists in BRL-CAD form. These geometric models are all Government owned and ready for immediate inclusion into engineering-level simulations and test & evaluation scenarios. While polygon-based simulators deem any model over 200 polygons as "high resolution," the BRL-CAD targets are modeled using about 1,000 CSG solids (10,000-20,000 polygon equivalents), and high resolution BRL-CAD targets range in complexity from 5,000 CSG solids to 40,000 CSG solids (800,000 polygon equivalents).

2. Computing thermal signatures is more difficult than computing optical signatures as objects in the scene can absorb heat and re-radiate it later. Thus, surface reflection models must be extended to include absorption and radiation effects. Two important examples of this include the hot tracks left behind when a tracked vehicle drives across cold ground, and the cold shadow left behind on a sunny day when a vehicle drives away from where it had been parked. Additionally, the diurnal cycle provides for important contrast reversals in the scene: in daytime trees appear cool against the warm sky, while at night the trees appear warm against the cold sky. Because different materials absorb and radiate heat at different rates, periods of contrast reversal can be very useful for locating targets, including buried mines and camouflaged vehicles.

**TECHNICAL APPROACH**

1. This project represents more of a systems integration effort, rather than an attempt to create new fundamental techniques. The resultant capability, however, will re-define the state of the art in thermal signature generation. There are three distinctly different aspects to this effort:

   A. First, the real-time ray-tracer needs to be extended into the multi-spectral domain, so that each pixel generated will not just be a simple red/green/blue triple, but will instead be a complex plot of received power (in physical units of milliwatts per square centimeter) versus wavelength. Spectral sampling density need not be uniform and will be user selectable, allowing the computation to focus on those portions of the spectrum of importance to the user. This will require the merging of the real-time parallel distributed high performance computing programs RTSYNC/RTNODE with the prototype multi-spectral synthetic image generator RTTHERM.

B. Second, the existing non-real-time SWOE algorithmic technology for tree, target, and sky thermal simulation and the existing NVESD technology for ground, target, and mine thermal simulation need to be re-formulated and re-coded in the context of modern high performance parallel processors, and then linked into the BRL-CAD Simulation Backplane. This will provide temperature data for every entity in the scene to the synthetic image generator, but more importantly, the thermal solvers will also gain access to the overall scene geometry, allowing full coupling between the different thermal solvers. For example, if a target is parked under a tree or in the shadow of a mountain ridge, that condition will be properly coupled, even if only a portion of the vehicle is in shadow. Similarly, the hot exhaust from the vehicle will heat the branches of the tree above it and the ground around it.

C. Third, the purely emissive surface model used in RTTHERM and the purely reflective surface model used in RTSYNC/RTNODE need to be replaced with a BRDF (bi-directional reflectance distribution function) based model which incorporates reflective, emissive, and absorptive phenomenology.

2. This effort will be proceeding in parallel with ARL's other efforts to create SWISS, the Synthetic Wide-band Imaging Spectraphotometer and Environmental Simulation, and the software created under this SIMTECH effort will be fully compatible with the SWISS system. Other parts of SWISS will provide atmospheric simulation, target motion, inclusion of countermeasures, vehicle and platform dynamics, modeling of phenomenology in other (non-IR) spectral bands, and the HLA interface.

3. The SWISS project is still in its infancy. However, already a number of videotapes have been produced to document the progress to date, most notably ``*Optical and IR Missile Sensor Simulation for ATR: Preliminary Results.*" For a more detailed discussion about the performance and optimization plans, please refer to the two companion papers: M. J. Muuss, *Towards Real-Time Ray-Tracing of Combinatorial Solid Geometric Models,* Proceedings of the BRL-CAD Symposium '95, Aberdeen Proving Ground, MD, 5-9 June 1995, and M. J. Muuss and M. Lorenzo, *High-Resolution Interactive Multi-Spectral Missile Sensor Simulation for ATR and DIS*, Proceedings of the BRL-CAD Symposium '95, Aberdeen Proving Ground, MD, 5-9 June 1995. These reports are available on the World-Wide-Web at http://ftp.arl.mil/~mike/papers/95cadsymp.

## PRODUCTS

1. The primary product of this effort will be a new version of the BRL-CAD real-time ray-tracer, expanded to include the multi-spectral capabilities of RTTHERM, with embedded and real-time interfaces to a ground thermal model, a tree thermal model, the PRISM target thermal model, and a multi-spectral BRDF-based energy reflection model.

2. These program can be run by DoD users on an HPC computer to conduct real-time experiments. The software will be portable to similar systems elsewhere (such as at MICOM) as well as to smaller systems. We propose that RTTHERM becomes part of the BRL-CAD core software, so that everyone in the modeling and simulation communities can take advantage of it.

3. This effort will also produce a series of HTML Web pages which will provide full user documentation.

## MILESTONES

| | |
|---|---|
| 1Q FY98 | Demonstrate real-time version of RTTHERM. |
| 2Q FY98 | Demonstrate linkage from RTTHERM to the three thermal solvers. |
| 3Q FY98 | Demonstrate multi-spectral BRDF-based energy reflection in RTTHERM. |
| 4Q FY98 | Final software delivery and HTML documentation |

## RISK/BENEFIT ANALYSIS

1. This is an ambitious effort for a one man-year program. By staying carefully focused on the task of integrating existing technology and avoiding the temptation to embark on substantial technology improvements in the process, success will require nothing more than careful planning and hard work.

2. Areas (1) and (2) will be performed by Mr. Muuss of ARL, who is a recognized expert in BRL-CAD high-resolution geometry and high performance parallel processing, and area (3) will be performed by Mr. Jacobs of CECOM/NVESD, whose dissertation research was in the area of BRDF surface models.

3. There is little risk of technical failure in this project; each of the component technologies is already operational in an existing code. The risk is mainly from uncertainties in funding, which SIMTECH support will eliminate.

4. The benefit to the DoD accrues at several levels. (1) A near-real-time thermal image generator which embodies high-quality physics-based signature generation will have direct benefit to the RDT&E community. In particular we see the results of this effort having direct application to the TECOM Virtual Proving Ground (VPG) effort, as well as supplementing the capabilities of the more than 1800 existing BRL-CAD users throughout the Defense Department and industry. (2) Providing the near-real-time signature generation with an HLA interface will allow high-cost high-fidelity simulators to participate in critical decision-making studies. (3) This software should form the core of a new "Online Signature Prediction Server", a long-time dream of the R&D, Combat Simulation, and Intelligence communities.

**EXECUTABILITY**

All of the OMA funds received will be used for in-house manpower and travel expenses, estimated at 70% for ARL and 30% for CECOM. No contract support is planned.

*SIM-98-OCAR-01*

**PROJECT TITLE:** USAR Resources to Readiness (R2)

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## EXECUTIVE SUMMARY

The OCAR is developing a simulation tool to determine how POM resourcing causes readiness. It describes the linkages and relationships from OCAR down to TPU level. This model helps programmers maintain balance across the USAR POM by exposing the complex cause and effect relationships among the MDEPs and PEGs.

This SIMTECH project will build on this success, and provide a robust and far-reaching decision support system which may have applicability Army-wide. OCAR's project articulates the impact of changing resources in terms of risk: the risk of USAR units achieving readiness goals, and the ability of the force structure to achieve TAP strategic guidance. This follow-on work will enhance the relationships and algorithms, and further develop the quality of the data sources. This work will refine the predictive capabilities of the model, and enhance the usefulness of the model as a decision support system.

This prototype works because Army planners now link strategic guidance in TAP to specific MDEPs, which form the basis of the POM. Next, simulation software now handles complex data on powerful Pentium desktop computers, and generates output in an executive-ready format. These advances, and other Army and OCAR project work have enabled program analysts to develop a methodology which links resources to readiness.

## BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

1. The Office of the Chief, Army Reserve, Program Analysis & Evaluation (PA&E) requires a set of decision analysis techniques to enhance their capability to build an integrated set of programs, and clearly articulate how these programs support USAR missions directed in The Army Plan (TAP). The need for this capability is heightened by changes in the structure of the PEGs. There are six PEGs, focused on specific Title X issues. This distributes the USAR programs across all the PEGs. OCAR PA&E must have the ability to define integrated cases for programmatic funding across several PEGs, and present these positions in a clear and compelling manner to ensure that funds are made available to support USAR accomplishment of TAP missions.

2. The problem this toolset must address can be generally framed as follows:

   ***"What causes readiness in the USAR force, and how can OCAR-level management shape the environment to cause desired changes in readiness?"***

3. The emphasis in this project lies not only with *"what causes readiness"* but also with the web of cause, effect and feedback, made more complicated by adding the dimension of five POM years. The simulation software describes these causes and effects in terms of relationships and linkages between programs. Feedback loops, and the dimension of time are handled cleanly by the software. This methodology takes advantage of the POM analysts' functional expertise, and the strengths of the software in handling the complexity of the algorithms.

4. "*Shaping the environment*" is a primary responsibility of a resourcing headquarters, such as OCAR. This process is started in the annual POM drills, aimed at achieving a balanced program. This shaping is handled by a system of variables within the simulation which articulate command priorities and guidance in terms the simulation can operationalize.

5. Finally, *"cause desired changes in readiness"* is a function of how these command priorities are resourced. The TAP assigns missions, and the Chief, Army Reserve provides guidance to the POM development staff, as well as to the Comptroller and organizational commanders, regarding readiness goals, given finite resourcing levels in personnel, training and equipment. Since resources are finite, readiness goals may vary with affordability. The OCAR staff balances mission readiness with the reality of affordability. Readiness goals can vary, given an organization's missions.

6. Technically, this toolset provides the PA&E staff an ability to perform quick analysis of potential changes to resourced positions, and examine alternative funding excursions. This toolset is a simulation, rather than a resource distribution utility. This is a function of complexity, POM years and the web of interrelationships between programs. A change to one funding stream causes an impact on many other programs. A simulation toolset allows users to make small changes in one or more programs or variables, and observe the expected behavior of all the other programs. In this manner, OCAR executives can work within their complex POM environment, examining the impact on readiness of shifting priorities or resources.

## TECHNICAL APPROACH

1. First, POM-level resource management must be linked to a measurable outcome of readiness changes in the USAR force. Only in this manner can OCAR articulate a credible, reliable and compelling analysis that supports rational resourcing positions.

2. Second, the decision support system must use detailed input and aggregate this data

into an executive information system. The reliability of the output, predicted changes in readiness, is a function of the quality and detail of the input data. At the same time, the viability of the DSS at the executive/user level lies with its ability to portray rich detail in an abbreviated manner. The output must reflect the detail, but not allow the decision maker to be overwhelmed by that same detail.

3. Third, any DSS that assists in the POM development process must possess speed. The ability to change assumptions must be fast. The ability to update data and run another iteration must be fast. A great deal of the ability to influence the POM development process is dependent on the speed of accurate analysis.

4. Part of the first and second challenges can be met by using the FY 97 and 98 changes to the structure of TAP. The re-engineered TAP operationalizes strategic guidance down to Resource Task level, which is articulated in MDEPs. This linkage, from TAP strategic guidance to funded MDEPs, now allows programmers to articulate how MDEP resources are necessary to achieve TAP strategic missions. Programmers can describe how shifting resources in one PEG impacts POM balance, and their ability to meet TAP guidance.

5. The simulation database will receive input data from many sources, including PROBE, STANFINS, historical OCAR estimates, OPTEMPO data from OSMIS and the BLTM/TRM models, TAADS for SRC data and personnel authorizations.

6. The remaining challenges can be met using advances in commercial simulation software. Complex data, graphical outputs, simplified manipulation of input variables and changes to assumptions, as well as speed of problem design have been built into market leading software. The greatest challenges lie with the functional experts in articulating the linkages and relationships, and finitely describing the algorithms.

## PRODUCTS

This project will develop a simulator that can be used by the POM analyst to investigate the problems surrounding building a balanced POM which enables units to reach readiness objectives. Specifically, the "products" of the simulation are assessments of the risk involved in changing a level of MDEP funding. Risk is defined as the probability of increasing or decreasing the reported readiness of a USAR unit, or group of units.

## MILESTONES

| | |
|---|---|
| Start + 90 days | Complete review of existing map and simulation model with PEG staffs. |
| Start + 150 days | Complete review of algorithms with PEG staffs. |
| Summer, 1998 | Support summer POM drills with simulation tool. tool. Evaluate suitability of tool for use in planning and budgeting, as well as program development. |

## RISK/BENEFIT ANALYSIS

1. The prototype has demonstrated initial successes at the first IPR, and at General Office review. Work through September, 1997 will focus on developing models of the remaining PEGs, and the interrelationships. There is every reason to believe the simulation will continue to receive enthusiastic support, and produce valuable products.

2. Benefits to the Army include the potential to support a degree of standardization in the way the staff articulates linkages between the TAP and the POM. Further, since financial execution systems already link MDEP and AMSCOs, this system provides a methodology to view how resources support TAP missions all the way through execution.

3. The major risk involved in the project is the subjective nature of the concept of readiness, and the lack of quantitative metrics in some areas. Personnel and equipment readiness is normally expressed by counting people or things on hand or serviceable. This is useful, but not directly related to the ability to accomplish missions. Worse, training readiness is inherently subjective in AR 220-1 and the 2715 report. Congress, OSD and the QDR have all called for better readiness metrics. The project will have to gain consensus on acceptable metrics in order to articulate compelling cases for resources based on readiness.

**EXECUTABILITY**

1. The current work is being accomplished by a joint team of contractors and OCAR PA&E analysts. We envision this team to remain together through the follow-on project.

2. The project can be executed with the existing contract vehicle, OSMIS, which belongs to the U.S. Army Cost and Economic Analysis Center. The OCAR and USACEAC have a MOA covering our use of this contract vehicle.

# GLOSSARY

## Section I - Abbreviations

**AAE**
Army Acquisition Executive

**AAN**
Army After Next

**ABCS**
Army Battle Command System

**ACAT**
Acquisition Category

**ACR**
Advanced Concepts and Requirements

**ACT**
Advanced Concept and Technology

**ADCSOPS**
Assistant Deputy Chief of Staff for Operations and Plans

**ADE**
Army Data Encyclopedia

**ADO**
Army Digitization Office

**ADS**
Advanced Distributed Simulation

**AEA**
Army Enterprise Architecture

**AFOR**
Automated Forces

**AIMSSS**
Army Information on Models, Simulations, and Studies System

**AI**
Artificial Intelligence

**AIS**
Automated Information System

**ALSP**
Aggregate Level Simulation Protocol

**AMC**
U.S. Army Materiel Command

**AMG**
Architecture Management Group

**AMIP**
Army Model Improvement Program

**AMS GOSC**
Army Model and Simulation General Officer Steering Committee

**AMSAA**
Army Materiel Systems Analysis Activity

**AMSEC**
Army Model and Simulation Executive Council

**AMSMP**
Army Model and Simulation Management Program

**AMSMP WG**
Army Model and Simulation Management Program Working Group

**AMSO**
Army Model and Simulation Office

**AMSTR**
Army Model and Simulation Technology Review

**AR**
Army Regulation

**ARI**
U.S. Army Research Institute for Behavioral and Social Sciences

**ASA(FM&C)**
Assistant Secretary of Army for Financial Management and Comptroller

**ASA (M&RA)**
Assistant Secretary of the Army (Manpower and Reserve Affairs)

**ASA(RDA)**
Assistant Secretary of Army for Research, Development, and Acquisition

**ASWG**
Advanced Simulation Working Group

*Abbreviations*

**ATD**
Advanced Technology Demonstration

**AV 2010**
Army Vision 2010

**AWC**
U.S. Army War College

**AWE**
Advanced Warfighting Experiment

**C4I**
Command, Control, Communications, Computers and Intelligence

**C4ISR**
Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance

**CAA**
U.S. Army Concepts Analysis Agency

**CAIV**
Cost as an Independent Variable

**CASE**
Computer Aided Software Engineering

**CDAd**
Component Data Administrator

**CEAC**
Cost and Economic Analysis Center

**CG**
Commanding General

**CG, TRADOC**
Commanding General, U.S. Army Training and Doctrine Command

**CGF**
Computer Generated Forces

**CINC**
Commander-in-Chief

**CM**
Configuration Management

**COB**
Command Operating Budget

**COE**
Common Operating Environment

**COTS**
Commercial Off-The-Shelf

**CSA**
Chief of Staff of the Army

**DA**
Department of the Army

**DAB**
Defense Acquisition Board

**DARPA**
Defense Advanced Research Projects Agency

**DAS (R&T)**
Deputy Assistant Secretary for Research and Technology

**DCG**
Deputy Commanding General

**DCSINT**
Deputy Chief of Staff for Intelligence

**DCSLOG**
Deputy Chief of Staff for Logistics

**DCSOPS**
Deputy Chief of Staff for Operations and Plans

**DCSPER**
Deputy Chief of Staff for Personnel

**DCSSA**
Deputy Chief of Staff for Simulations and Analysis

**DDL**
Delegation of Disclosure Letter

**DDDS**
Defense Data Dictionary System

**DDRS**
Defense Data Repository System

**DEA**
Data Exchange Agreement

**DII**
Defense Information Infrastructure

**DIS**
Distributed Interactive Simulation

**DISA**
Defense Information Systems Agency

**DISC4**
Director of Information Systems for Command, Control, Communications, and Computers

**DISN**
Defense Integrated Services Network

**DMSO**
Defense Modeling and Simulation Office

**DMSTTIAC**
Defense Modeling, Simulation, and Tactical Technology Information and Analysis Center

**DoD**
Department of Defense

**DPRB**
Defense Planning and Resources Board

**DSI**
Defense Simulation Internet

**DTD**
Digital Topographic Data

**DUSA (IA)**
Deputy Under Secretary of the Army for International Affairs

**DUSA(OR)**
Deputy Under Secretary of Army for Operations Research

**EUSA**
Eighth U.S. Army

**EXCIMS**
Executive Council for Modeling and Simulation

**FFRDC**
Federally Funded Research and Development Center

**FMS**
Foreign Military Sales

**FOA**
Field Operating Agency

**FORSCOM**
U.S. Army Forces Command

**FTP**
File Transfer Protocol

**FY**
Fiscal Year

**GO**
General Officer

**GOSC**
General Officer Steering Committee

**GS**
General Schedule

**GUI**
Graphical User Interface

**HLA**
High Level Architecture

**HOL**
High Order Language

**HQDA**
Headquarters, Department of Army

**IA**
International Agreement

**IAW**
In Accordance With

**ICT**
Integrated Concept Team

**IDEF**
Integrated Definition Language

**IEA**
International Exchange Agreement

**IEEE**
Institute of Electrical and Electronic Engineers

**IPR**
In-Process Review

**IV&V**
Independent Verification and Validation

**JMASS**
Joint Modeling and Simulation System

**JROC**
Joint Requirements Oversight Council

**JSIMS**
Joint Simulation System

**JTA**
Joint Technical Architecture

**JTA - Army**
Joint Technical Architecture - Army (formerly the Army Technical Architecture (ATA))

**LOA**
Letter of Agreement

**MACOM**
Major Army Command

*Abbreviations*

**MAIS**
Major Automated Information Systems

**MAISRC**
Major Automated Information Systems Review Council

**MAP**
Mandatory Procedures for Major Defense Acquisition Programs

**MDA**
Milestone Decision Authority

**MDEP**
Management Decision Package

**M&S**
Model(s) and Simulation(s) - Used in singular and plural

**MNS**
Mission Needs Statement

**MOA**
Memorandum of Agreement

**ModSAF**
Modular Semi-Automated Forces

**MOOTW**
Military Operations Other Than War

**MSEA**
M&S Executive Agent

**MSIS**
Model and Simulation Information System

**MSOSA**
Modeling and Simulation Operational Support Activity

**MSRD**
Model and Simulation Requirements Document

**MSRR**
Model and Simulation Resource Repository

**MTMCTEA**
Military Traffic Management Command Transportation Engineering Agency

**NGB**
National Guard Bureau

**NIMA**
National Imagery and Mapping Agency

**NPR**
National Performance Review

**NSTD**
Non-System Training Device

**OCAR**
Office of the Chief, Army Reserve

**OGC**
Office of the General Counsel

**OMA**
Operations and Maintenance, Army

**OneSAF**
One Semi-Automated Force

**OPA**
Other Procurement, Army

**OPTEC**
U.S. Army Operational Test and Evaluation Command

**ORD**
Operational Requirements Document

**OSA**
Office of Secretary of the Army

**OSD**
Office of the Secretary of Defense

**P&A**
Price and Availability

**PAED**
Army Program Analysis and Evaluation Directorate

**PAO**
Public Affairs Office(r)

**PDU**
Protocol Data Unit

**PEG**
Program Evaluation Group

**PEO**
Program Executive Officer

**PM**
Program Manager

**POC**
Point of Contact

**POM**

Program Objective Memorandum

**PPBES**
Planning, Programming, Budgeting, and Execution System

**PPBS**
Planning, Programming, and Budgeting System

**PBD**
Program Budget Decision

**QA**
Quality Assurance

**R&D**
Research and Development

**RDA**
Research, Development, and Acquisition

**RDT&E**
Research, Development, Test and Evaluation

**RFP**
Request for Proposal

**RIA**
Requirements Integration and Approval

**RIC**
Requirements Integration Council

**RIWG**
Requirements Integration Working Group

**S&T**
Science and Technology

**SAF**
Semi-Automated Force

**SBA**
Simulation Based Acquisition

**SCC**
Standards Category Coordinator

**SEDRIS**
Synthetic Environment Data Representation and Interchange Specification

**SES**
Senior Executive Service

**SIMTECH**
Simulation and Technology Program

**SMDC**
U.S. Army Space and Missile Defense Command

**SOW**
Statement of Work

**SRD**
Standards Requirement Document

**SSA**
Staff Support Agency

**SSP**
Simulation Support Plan

**STAMIS**
Standard Management Information System

**STOW**
Synthetic Theater of War

**STOW-A**
Synthetic Theater of War-Architecture

**STRICOM**
Simulation, Training, and Instrumentation Command

**T&E**
Test and Evaluation

**TAFIM**
Technical Architecture Framework for Information Management

**TEA**
Transportation Engineering Agency

**TEC**
Topographic Engineering Center

**TEMO**
Training Exercises and Military Operations

**TOC**
Tactical Operations Center

**TP**
TRADOC Pamphlet

**TPO**
Technical Project Officer

**TRAC**
TRADOC Analysis Center

**TRADOC**
U.S. Army Training and Doctrine Command

**TRANSCOM**
U.S. Transportation Command

**USACAA**
U.S. Army Concepts Analysis Agency

**USACE**

U.S. Army Corps of Engineers

**USAREUR**
U.S. Army Europe

**USARPAC**
U.S. Army Pacific

**USARSO**
U.S. Army, South

**USASAC**
U.S. Army Security Assistance Command

**USASOC**
U.S. Army Special Operations Command

**VCSA**
Vice Chief of Staff of the Army

**V&V**
Verification and Validation

**VV&A**
Verification, Validation, and Accreditation

**VV&C**
Verification, Validation, and Certification

**WARSIM**
Warfighters' Simulation

**WG**
Working Group

**WWW**
World Wide Web

## Section II - Terms

**Accreditation**
The official determination that a model, simulation, or federation of M&S is acceptable for use for a specific purpose.

**Accreditation Agent**
The organization designated by the application sponsor to conduct an accreditation assessment for a M&S application.

**Accreditation Criteria**
A set of standards that a particular model, simulation, or federation of M&S must meet to be accredited for a specific purpose.

**Advanced Concepts and Requirements (ACR) Domain**
One of the three domains for Army M&S applications. ACR includes experiments with new concepts and advanced technologies to develop requirements in doctrine, training, leader development, organizations, materiel and soldiers which will better prepare the Army for future operations. ACR evaluates the impact of horizontal technology integration through simulation and experimentation using real soldiers in real units.

**Advanced Distributed Simulation (ADS)**
A set of disparate M&S operating in a common synthetic environment within which humans may interact at multiple sites networked using compliant architecture, modeling, protocols, standards, and data bases. The ADS may be composed of three modes of simulation-- live, virtual, and constructive which can be seamlessly integrated.

**Analysis**
A broad category of study and investigation which includes support to operational, tactical, and strategic decision making.

**Analysis of Alternatives**
A study conducted to provide support for acquisition decisions in the acquisition cycle. The AoA illuminates the relative advantages and disadvantages of the alternatives being considered showing the sensitivity of each alternative to possible changes in key assumptions (e.g., threat) or variables (e.g., performance capabilities). There shall be a clear linkage between the AoA, system requirements, and system evaluation measures of effectiveness.

**Application**
A specific, individual project session that requires or uses an M&S to achieve its purpose.

**Application Sponsor**
The organization that utilizes the results or products from a specific application of a model or simulation.

**Architecture**
The structure of components in a program/system, their relationships, and the principles and guidelines governing their design and evolution over time.

**Army Enterprise Architecture (AEA) Master Plan**
An integrated plan of action for accomplishing Army-wide information technology and investment strategies to accomplish the Joint Vision and the Army Vision 2010. It documents the total AEA and specifies the information systems programs and resource requirements necessary to support stated sessions and objectives.

**Army Model and Simulation Standards Report**
The Army Model and Simulation Standards Report contains the yearly status of Army efforts to standardize model and simulation techniques and procedures. It also reflects the Army's yearly model and simulations investments throughout the Army Model Improvement Program (AMIP) and the Simulation Technology (SIMTECH) Program.

**Automated Information System (AIS)**
A combination of information, computer hardware, software, personnel, and telecommunications resources that collects,

records, processes, stores, communicates, retrieves, and/or displays information.

**Common Use M&S**
M&S applications, services, or materials provided by a DoD Component to two or more DoD components.

**Computer Generated Forces**
A capability/technology where computer generated forces are a doctrinally correct representation of both friendly and opposing forces. These forces will support simulations by providing opposing forces, supporting forces, and forces needed to permit a smaller number of personnel to represent a much larger force.

**Configuration Management**
The application of technical and administrative direction and surveillance to identify and document the functional and physical characteristics of a M&S, control changes, and record and report change processing and implementation status.

**Constructive M&S**
M&S that involve real people making inputs into a simulation that carries out those inputs by simulated people operating simulated systems.

**Data Certification**
The determination that data have been verified and validated. Data user certification is the determination by the application sponsor or designated agent that data have been verified and validated as appropriate for the specific M&S usage. Data producer certification is the determination by the data producer that data have been verified and validated against documented standards or criteria.

**Data Exchange Standard**
Formally defined protocols for the format and content of data messages used for interchanging data between networked simulation and/or simulator nodes used to create and operate a distributed, time and space coherent synthetic environment. Current standards include ALSP and DIS Protocol Data Units.

**Data Proponent**
The agency or organization that has primary responsibility for a Data collection or data base. The proponent develops the requirement for the data.

**Data Standards**
A capability that increases information sharing effectiveness by establishing standardization of data elements, data base construction, accessibility procedures, system communication, data maintenance and control.

**Data Validation**
The documented assessment of data by subject area experts and its comparison to known values. Data user validation is an assessment as appropriate for use in an intended M&S. Data producer validation is an assessment within stated criteria and assumptions.

**Data Verification**
Data producer verification is the use of techniques and procedures to ensure that data meets constraints defined by data standards and business rules derived from process and data modeling. Data user verification is the use of techniques and procedures to ensure that data meets user specified constraints defined by data standards and business rules derived from process and data modeling, and that data are transformed and formatted properly.

**Data Verification, Validation, and Certification**
The process of verifying the internal consistency and correctness of data, validating that it represents real world entities appropriate for its intended purpose or an expected range of purposes, and certifying it as having a specified level of quality or as being appropriate for a specified use, type of use, or range of uses. The process has two perspectives-- producer and user process.

**Defense Simulation Internet (DSI)**
A wide band telecommunications network operated over commercial lines with connectivity to both military and civilian satellites allowing users to be linked on a

world-wide, wide area network.

**Distributed Interactive Simulation (DIS)**
A subset of advanced distributed simulation which interfaces through the use of DIS Protocol Data Units.

**DIS Compatible**
Two or more simulations/simulators are DIS compatible if (1) they are DIS compliant and (2) their models and data that send and interpret protocol data units support the realization of a common operational environment among the systems (coherent in time and space).

**DIS Compliant**
A simulation/simulator is DIS compliant if it can send and receive protocol data units in accordance with IEEE Standard 1278 and 1278 (Working Drafts). A specific statement must be made regarding the qualifications of each protocol data unit.

**Dynamic Environment**
The environment is constantly changing as a result of man-made efforts (battlefield smoke) and natural phenomenon (weather). Incorporating dynamic environment into real time simulations provides a more realistic test bed for weapons, equipment, and personnel.

**Emulator**
A physical M&S which duplicates the behavior, properties, or performance of another system. Emulators are frequently used to generate inputs for other M&S.

**Fair Fight**
Two or more simulations may be considered to be in a fair fight when differences in the simulations' performance characteristics have significantly less effect on the outcome of the conflict than actions taken by the simulation participants.

**Federation Element**
Term applied to an individual M&S that is part of a federation of models and simulations. Federation elements may be distributed.

**Federation of Models and Simulations**
A system of interacting M&S with supporting infrastructure, based on a common understanding of the objects portrayed in the system.

**Firmware**
The combination of a hardware device and computer instructions or computer data that reside as read-only software on the hardware device. The software cannot be readily modified under program control.

**General-use M&S Applications**
Specific representations of the physical environment or environmental effects used by, or common to, many M&S (e.g., terrain, atmospheric, or hydrographic effects).

**High Level Architecture**
Major functional elements, interfaces, and design rules, pertaining, as feasible, to all DoD simulation applications, and providing a common framework within which specific system architectures can be defined.

**Independent Verification and Validation (IV&V)**
The conduct of verification and validation of M&S by individuals or agencies that did not develop the M&S. IV&V does not require complete organizational independence, but does imply a reasonable degree of organizational separation to assure unbiased analysis.

**Interoperability**
The ability of a set of M&S to provide services to and accept services from other M&S and to use the services so exchanged to enable them to operate effectively together.

**Live Simulation**
A representation of military operations using live forces and instrumented weapon systems interacting on training, test, and exercise ranges which simulate experiences during actual operational conditions.

**Management threshold**
The threshold or limit, as defined by management, when a M&S passes from the management considerations of one category or level to the management considerations of another category.

**Model**

A model is a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process.

**Model Types**

*a. Physical model.* A physical representation of the real world object as it relates to symbolic models in the form of simulators.

*b. Mathematical model.* A series of mathematical equations or relationships that can be discretely solved. This includes M&S using techniques of numerical approximation to solve complex mathematical functions for which specific values cannot be derived (e.g., integrals).

*c. Procedural model.* An expression of dynamic relationships of a situation expressed by mathematical and logical processes. These models are commonly referred to as simulations.

**M&S Developer**
The organization responsible for developing, managing or overseeing M&S developed by a DoD component, contractor, or Federally Funded Research and Development Center. The developer may be the same agency as the proponent agency.

**M&S Activity**
The development and maintenance of a computer-based M&S capability by or for organizations of the U.S. Army.

**M&S Proponent**
The organization responsible for initiating the development and directing control of the reference version of a model or simulation. The proponent will develop and execute a viable strategy for development and maintenance throughout the life cycle of the M&S; and for directing the investment of available resources in same. The M&S proponent serves as the advocate and final authority on their M&S. The proponent will advise the DUSA(OR) on release of the M&S to foreign countries, and will advise the MACOM or Organizational Release Authority for domestic release. Except where responsibilities are specifically designated to an acquisition official by DoD or DA policy e.g. DoD 5000.2 or AR 70-1, the M&S proponent is responsible for, but may delegate execution of: M&S Development; Configuration Management; Preparation and Maintenance of Simulation Object Models (SOMs) as appropriate; all aspects of Verification and Validation; and maintenance of current information in all catalogs and repositories.

**Modeling and Simulation**
The development and use of live, virtual, and constructive models including simulators, stimulators, emulators, and prototypes to investigate, understand, or provide experiential stimulus to either (1) conceptual systems that do not exist or (2) real life systems which cannot accept experimentation or observation because of resource, range, security, or safety limitations. This investigation and understanding in a synthetic environment will support decisions in the domains of research, development, and acquisition (RDA) and advanced concepts and requirements (ACR), or transfer necessary experiential effects in the training, exercises, and military operations (TEMO) domain.

**Non-System Training Device (NSTD)**
A training device or simulation which is not directly identified with a unique weapons system, but rather has application over a wide spectrum of potential users (e.g., WARSIM). The NSTD process is governed by the AR 70 series.

**Open Systems Environment**
The fielding of hardware and software products that are interoperable and portable. The objective is to promote competition by allowing systems developed by multiple vendors and nations to interoperate through a common set of computer and communications protocols.

**Pre-Processor**
A software (and sometimes hardware) unit which conditions or prepares data before the data is input into a model or simulation. Example: A code which converts metric data from cartesian (rectangular) coordinates to

flight coordinates (Euler angles) prior to its being input into an aircraft or guided missile model.

**Post Processor**
A software (and sometime hardware) unit which conditions data after it is output by a model or simulation, in order to adapt it to a human analyst/observer or to another model. Example: A code which converts streams of metric measurement data from a simulation into a graphic representation of a scene as viewed from the perspective of an aircraft or missile.

**Proponent**
See M&S Proponent or Data Proponent

**Protocol Data Unit (PDU) Standards**
In accordance with IEEE Standard 1278, formally defined data exchange standards established for each of the several primary classes of functionality which is represented in the DIS synthetic environment (e. g. movement, weapons, firing effects, collisions, etc.).

**Reference Version**
The most recent version of a M&S which has been released for community use by, and under configuration management of, the M&S users group executive committee.

**Research, Development, and Acquisition (RDA) Domain**
One of the three domains for Army M&S applications. Includes all M&S used for design, development, and acquisition of weapons systems and equipment. M&S in the RDA domain are used for scientific inquiry to discover or revise facts and theories of phenomena, followed by transformation of these discoveries into physical representations. RDA also includes test and evaluation (T&E) where M&S are used to augment and possibly reduce the scope of real-world T&E.

**Simulation**
A method for implementing a model(s) over time.

**Simulator**
a. A device, computer program, or system that performs simulation.
b. For training, a device which duplicates the essential features of a task situation and provides for direct practice.
c. For Distributed Interactive Simulation (DIS), a physical model or simulation of a weapons system, set of weapon systems, or piece of equipment which represents some major aspects of the equipment's operation.

**Sponsoring Agency**
The agency which sponsors the development or use of M&S utilizing either in-house, other government agency, or contract resources.

**Standard**
A rule, principle, or measurement established by authority, custom, or general consent as a representation or example.

**Standards Categories**
The elements of the framework for M&S standards development. The Standards framework contains all the things the Army M&S community seeks to represent algorithmically, devolved into Categories which are assigned to the Army agencies best suited to coordinate development and maintenance of standards in the technical regime represented by that category.

**Stimulator**
*a.* A hardware device that injects or radiates signals into the sensor system(s) of operational equipment to imitate the effects of platforms, munitions, and environment that are not physically present.
*b.* A battlefield entity consisting of hardware and/or software modules which injects signals directly into the sensor systems of an actual battlefield entity to simulate other battlefield entities in the virtual battlefield.

**Symbolic M&S**
M&S which represent a real system using mathematical equations or computer programs. Symbolic M&S are contrasted from other representations such as maps, board games, field exercises, and mockups.

**Synthetic Environments (SE)**

Internetted simulations that represent activities at a high level of realism from simulations of theaters of war to factories and manufacturing processes. These environments may be created within a single computer or a vast distributed network connected by local and wide area networks and augmented by super-realistic special effects and accurate behavioral models. They allow visualization of and immersion into the environment being simulated. (Ref. DoD 5000.59-P; CJSI 8510.01)

**Technical Architecture**
A minimal set of rules governing the arrangement, interaction, and interdependence of the parts or elements that together may be used to form an information system, and whose purpose is to insure that a conformant system satisfies a specified set of requirements.

**Test and Evaluation (T&E)**
Test and evaluation includes engineering, developmental, and operational tests.

**Training Effectiveness Analysis (TEA)**
A study conducted by TRADOC Analysis Center (TRAC) to determine the adequacy of the operator, maintainer, unit, and institutional training for new equipment which is fielded. TEAs evaluate training environment, training devices, soldier hardware-software interface, and military occupational specialty selection criteria.

**Training, Exercises, and Military Operations (TEMO) Domain**
One of the three domains for Army M&S applications. TEMO includes most forms of training at echelons from individual simulation trainers through collective, combined arms, joint, and/or combined exercises. TEMO includes mission rehearsals and evaluations of all phases of war plans. Analysis conducted during the rehearsal or evaluation validates the plan as best as the simulation environment will allow.

**Validation**
The process of determining the extent to which a M&S is an accurate representation of the real-world from the perspective of the intended use of the M&S. Validation methods include expert consensus, comparison with historical results, comparison with test data, peer review, and independent review.

**Validation Agent**
The organization designated by the M&S sponsor to perform validation of a model, simulation, or federation of M&S.

**Verification**
The process of determining that a M&S accurately represents the developer's conceptual description and specifications. Verification evaluates the extent to which the M&S has been developed using sound and established software engineering techniques.

**Verification Agent**
The organization designated by the M&S sponsor to perform verification of a model, simulation, or federation of M&S.

**V&V Agent**
The organization designated by the M&S sponsor to perform verification and validation of a model, simulation, or federation of M&S.

**V&V Proponent**
The government agency responsible for ensuring V&V is performed on a specific M&S.

**Virtual M&S**
A synthetic representation of warfighting environments patterned after the simulated organization, operations, and equipment of actual military units.

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