Army Model and Simulation Standards Report FY00

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The *Army Model and Simulation Standards Report for FY00* contains the status of the Army's efforts to develop M&S standards. It also provides a preview of Army Model Improvement Program (AMIP) and Simulation Technology Program (SIMTECH) projects approved for funding in FY00.

Standardizing the Army's M&S processes is a vital step toward realizing the full potential of modeling and simulation. The Army's efforts to establish M&S standards directly supports the joint industry and Department of Defense Simulation Based Acquisition (SBA) initiative and promotes efficient business practices. I continue to expect each standards category coordinator and team to be active, alert, and in touch with the rest of the M&S community in order to turn the Army's vision for the future into action.

Our standards development efforts continue to gain positive momentum. We must continue to build on that momentum and attack the challenges that lie ahead.

WENDELL H. LUNCEFORD
Director, Army Model and Simulation Office

Army Model and Simulation Standards Report FY00

INTRODUCTION AND PURPOSE

The *Army Model and Simulation Standards Report FY00* provides a snapshot of the Army's Model and Simulation (M&S) standards efforts as work progresses towards the objective Army M&S environment. This report provides a summary of the annual activities within each standards category team and documents projects approved for funding through the Army Model Improvement Program (AMIP) and the Simulation Technology (SIMTECH) program. It also provides background information on the standards categories, the organizations, and individuals involved in the Army's M&S Standards Development Process.

Vital investments occur under both the AMIP and SIMTECH programs. In August 1999, the Army Model and Simulation Office (AMSO) convened a meeting of the Policy and Technology Working Group (P&T WG) to evaluate and prioritize proposed AMIP and SIMTECH projects for FY00. The Army Model and Simulation Executive Committee reviewed the prioritized list of projects (Appendices D and E) and made recommendations to the Deputy Under Secretary of the Army for Operations Research (DUSA(OR)), the final approval authority for AMIP and SIMTECH funding.

Since the publication of last year's Standards Report, a new Standards Category has been added – Visualization, and the Architecture category was redesignated as System Design and Architecture to more accurately reflect its direction. In addition, the Emulation and Stimulation area of special interest was retired at the request of its sponsor.

THE ARMY MODEL IMPROVEMENT PROGRAM

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 that further the objectives within their respective category. The project nominations are included as part of each SCC's Annual Standards Category Report. The SCCs and their team prioritize multiple nominations to indicate which project addresses the most pressing standards requirement within that category. The nominations are integrated and prioritized by the P&T WG and submitted through the AMSEC to the DUSA (OR) for approval. Additional project nomination guidance can be found in Appendix B of the *Army M&S Master Plan*.

SIMULATION TECHNOLOGY PROGRAM

The SIMTECH program complements the AMIP. Where the AMIP invests in technologies that are fairly well developed and have a high probability of developing a standard, 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. Starting in

FY00, SIMTECH will focus on potential high payoff M&S areas. The specific areas we will pursue in the near term include:

- Expeditious and accurate generation of terrain data
- Threat representation and development of standard methods and common requirements for data generation
- Integration of real world C4ISR systems with simulations
- Representation of human behaviors, to include command decision modeling within simulations
- Modeling to facilitate analysis of (joint) mobilization issues
- Integration of logistics within combat simulations.

Proposals considered for FY01 funding will be limited to these areas.

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 standards needs. Additional project nomination guidance is contained in Appendix B of the *Army M&S Master Plan*.

The Army's Model and Simulation Standards Development Process

WHAT IS AN ARMY M&S STANDARD?

Webster's II New Riverside University Dictionary defines a standard as "a rule, principle, or measurement established by authority, custom, or general consent as a representation or example." The term M&S 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. The Army M&S Master Plan describes three levels of standards. Draft Standards are initial or proposed standards. These standards have not completed the review and approval process. Approved standards are the next higher-level. These standards have been reviewed and demonstrated sufficient maturity and consensus to warrant their recommendation to the Deputy Under Secretary of the Army for Operations Research (DUSA (OR)) for approval. Mandatory Standards are the highest-level of standards and are promulgated by regulation or policy statement. Developers and users of Army M&S systems must follow these standards. An example of a mandatory standard is the DOD High Level Architecture for simulations. 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.

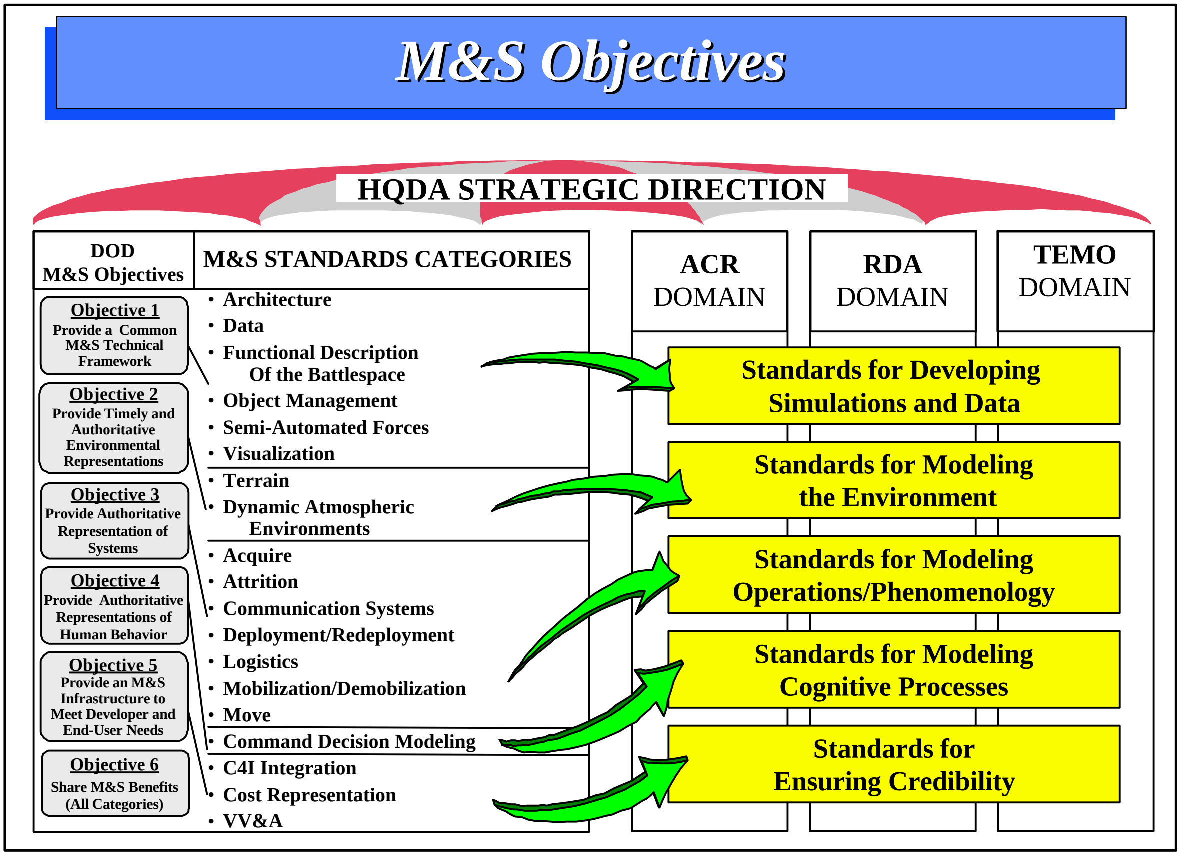

FIGURE 2. DoD M&S Objectives

WHY ESTABLISH ARMY M&S STANDADS

Simply put, the Army seeks to develop standards to improve M&S interoperability and credibility while also increasing its commonality and reuse. By developing M&S standards the Army hopes to:

- enable simulations to provide or accept services from one another thus making them more interoperable;
- improve the credibility or acceptance on the correctness of M&S representations;
- increase the commonality of the way the synthetic environment is depicted; and
- establish a baseline for reusing standard algorithms and heuristics in future simulations.

In addition, having M&S standards makes the process of Verification and Validation (V&V) both simpler and faster, and creates the opportunity for the Army's analytical, acquisition, and training communities to leverage their simulation development off of each other's efforts.

THE ARMY'S SEVEN STEP STANDARDS DEVELOMENT PROCESS

The Army's M&S standards development is consensus-based by choice. M&S technologies evolve at blinding speeds. Some technological niches turn over in a matter of months. Technological, procedural, and application advances take place within a myriad of organizations in the Army, and throughout the commercial and academic sectors. Attempting to centralize the authority for establishing standards, without devoting major resources to the effort, would not enable the Army to remain a M&S community leader. Rather, it could place the Army permanently behind the rest of the M&S community. No single Army office or organization is capable of effectively investigating and making the necessary decisions to evolve Army models and simulations that keep pace with the rest of the industry. By keeping the process consensus-based, those decisions are in the hands of the real Army M&S experts.

<u>*Build Teams*</u>. Subject matter experts from various organizations throughout the Army are appointed to serve as Standards Category Coordinators (SCCs). They are not executive agents. They serve as the leadership for developing M&S standards within their standards category. They are empowered to develop their teams drawing on the mix of talents and expertise needed in their specific area. Team composition is interdisciplinary and represents organizations across DOD, industry, and academia. Membership is based on inclusion rather than exclusion.

<u>*Define Requirements*</u>. The second step is to define requirements. With only limited resources to devote to the development of standards, it is essential to keep the work of the team focused on the most important issues. Any individual may identify a new M&S standard requirement, may request that an existing algorithm or technique become a standard, or recommend an existing standard be modified. The AMSO then coordinates validation of the proposed requirement with the appropriate SCC, the Army's three M&S domain representatives (Advanced Concepts and Requirements; Research, Development, and Acquisition; and Training, Exercises, and Military Operations), and other key players as necessary to ensure that the proposal supports a community need. After validation of the requirement is completed, the initiator is provided feedback. A proposed standard could be an excellent idea but may fail to fit a "market niche". If the proposal is approved, it then moves on to the Develop Standards step of the process.

<u>*Develop Standards*</u>. This is the crux of the standards development process. The wider the involvement of experts across the M&S community, the more likely each category will capture those algorithms, heuristics, and techniques – as well as "best and current practices" – that warrant becoming Army M&S standards.

<u>Achieve Consensus</u>. After the standard has been developed, the next step is to achieve consensus. Because the process is continuous and iterative, the community more readily adopts standards they feel can be modified and improved over time. Each draft standard may go through several iterations before being embraced by the group and reaching consensus. The primary tool that each Standards Category (SC) team uses to "hammer-out" or achieve consensus on a draft standard is an electronic mail reflector or list server. By using reflectors as the primary method to conduct the discussion, all interested parties can get involved. The beauty of this method is that an individual in government, industry, or academia can join various SC teams and actively participate without incurring costly travel expenses.

<u>Obtain Approval</u>. Once consensus has been achieved, the draft standard is then reviewed by a panel of Senior Army M&S subject matter experts who determine if the proposed standard should be forwarded to the DUSA (OR) for approval or if it should be returned to the SC team for additional work.

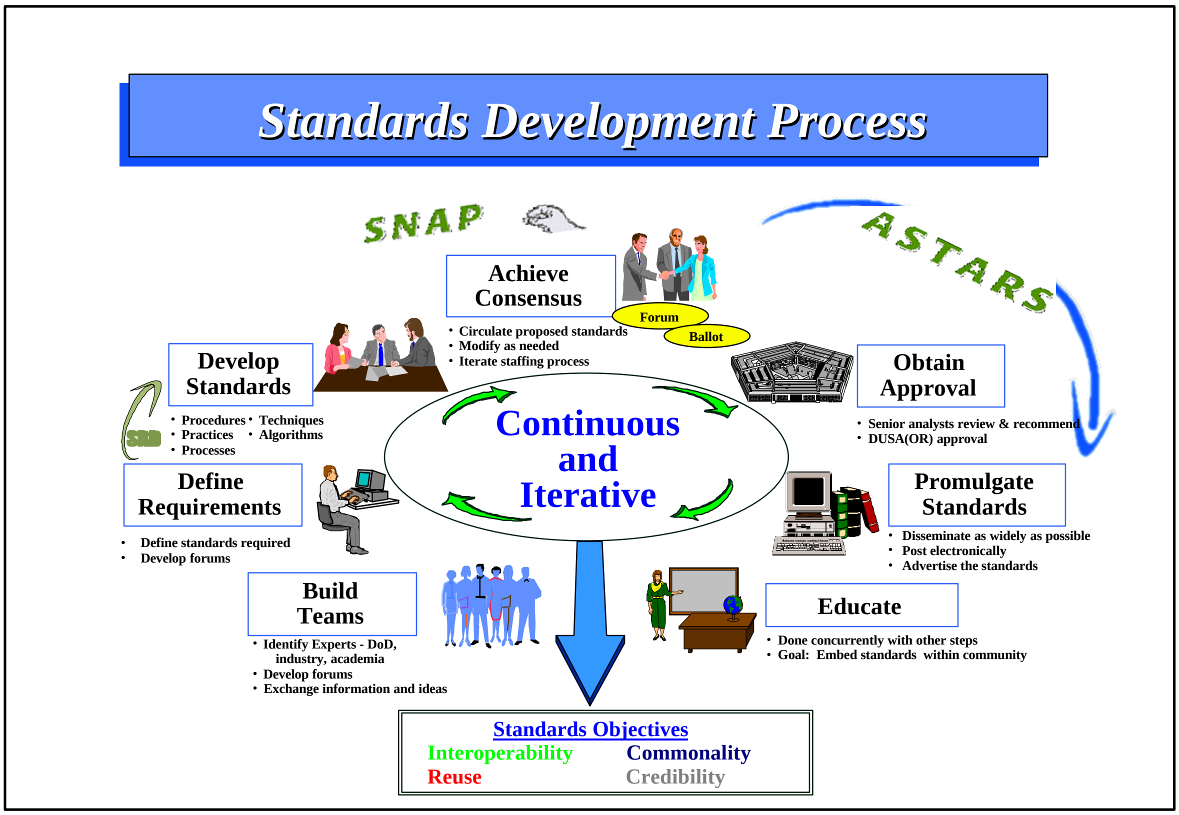

FIGURE 3. The Army's M&S Standards Development Process

<u>Promulgate Standards</u>. Every approved Army M&S standard, as well as related documents and tools, will be registered in the Army portion of the DoD Modeling and Simulation Resource Repository (MSRR). Each SCC has established an Internet Home Page to provide specific information pertaining to their category. Information on all the

aspects of M&S Standards can be accessed from both the AMSO Home Page and the Army Node of the Modeling and Simulation Resource Repository (MSRR).

Educate. Educating and assisting modelers and users is accomplished concurrently with the other steps. The more active the standards category coordinator is, the more educated the community. Once a standard has been approved, the team begins educating the M&S community on the availability, applicability, and use of the standard.

SNAP

The Standards Nomination and Approval Process (SNAP; http://www.msrr.army.mil/snap) is the tool that facilitates executing four steps of the Army M&S Standards Development Process: 1) define requirements, 2) develop standards, 3) achieve consensus, and 4) obtain approval. From the beginning of its development, in May 1997, SNAP was fully integrated into the Army's seven step M&S Standards Development Process.

At the heart of SNAP is the Standards Requirement Document (SRD). The SRD, an on-line form, is the first step in developing a new Army M&S standard; refining an existing standard; or nominating an accepted M&S practice, procedure, or technique to become a standard. The overall SRD format is consistent with the M&S Requirements Document so it can easily be integrated into the Army M&S Requirements Integration and Approval Process if necessary.

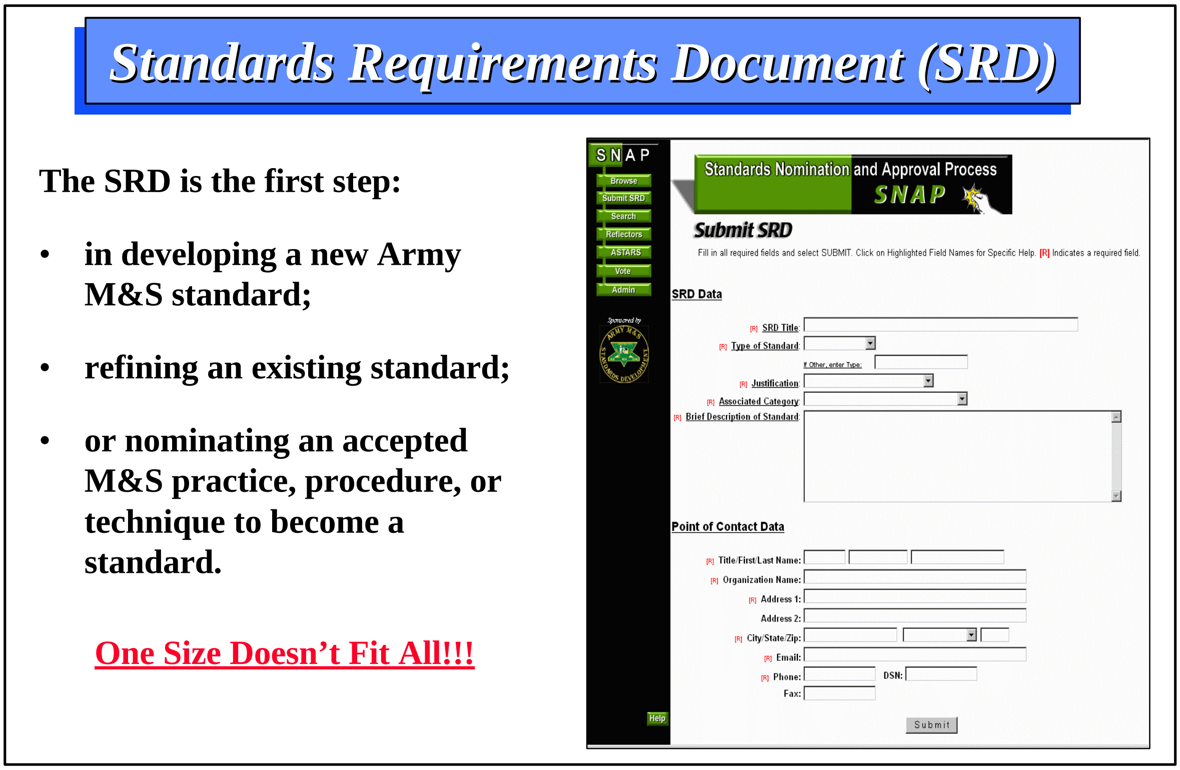

FIGURE 4. The Standards Requirements Document

To assist AMSO, SCCs, and interested parties in the tracking of a draft standard, SNAP has both a browse and a search capability. Browse allows a user to see a list of all in process and approved standards sorted in ascending SRD number. Additionally, while in Browse, a user can elect to change how draft standards are displayed, specifically by sorting them by SRD Number, Current SRD Status (All, In Process, or Approved), or Standards Category.

SNAP also has a built-in search engine which, when selected, brings up its Fast Find / Search page. This page is divided horizontally into two sections. The Fast Find section offers a user the ability to find an in process or approved standard by its' SRD Number and the first 60 characters of its title. The Search section contains a query dialog box containing AND / OR logic fields and input fields that enable the user to conduct a more thorough search.

Also part of SNAP, is an electronic mail reflector that echoes all messages to all current subscribers. Thus, by sending a message to a reflector, all subscribers receive a copy even though the message wasn't addressed to each of them directly.

Each Standards Category has a reflector and they are used extensively in the Army M&S Standards Approval Process as a forum to develop and achieve consensus on draft standards. SNAP monitors this traffic and – as part of its database – maintains a copy of every reflector message sent. For those who have just joined a Standards Category, or for old hands, this feature allows one to review the on going debate on one or more draft standards and eliminates the need for current subscribers to maintain a copy of every reflector message sent. This unique feature permits individuals to enter the debate at any time during the define requirements, develop standards, or achieve consensus steps. SNAP also uses its reflectors to notify current subscribers of a given standards category when a draft standard is being developed or is being voted upon.

When a SCC has determined that consensus has been achieved on a draft standard, they can recommend to AMSO that the standard be forwarded to that category's Senior Reviewers for voting. If approved by AMSO, SNAP will automatically send an electronic mail message to each appropriate Senior Reviewer. This message will contain a "hot-link" to that Senior Reviewer's voting page along with information on the draft standard. Provided they have Internet access, the Senior Reviewer can select the "hot link" and move directly to their voting page. Senior Reviewers may either vote "Yes" or "No". When they vote "No" a comment field must be completed or the vote will not be accepted. If the comment field is completed, an electronic message is automatically sent to both AMSO and the appropriate SCC. Every effort will be made to resolve the Senior Reviewer's concerns prior to the closure of voting.

ASTARS

For each standard in the Army Standards Repository System (ASTARS; http://www.msrr.army.mil/astars), you will find information about the standard and a government point-of-contact. To the maximum extent practical, all of the items described in ASTARS will be available to the public for download or linked to another web site where the standard is available for download. Standards in ASTARS can be password-protected when access needs to be limited. However, classified standards will not be stored in ASTARS. Those standards not available for public release will follow the release procedures for M&S standards described in Army Regulation 5-11.

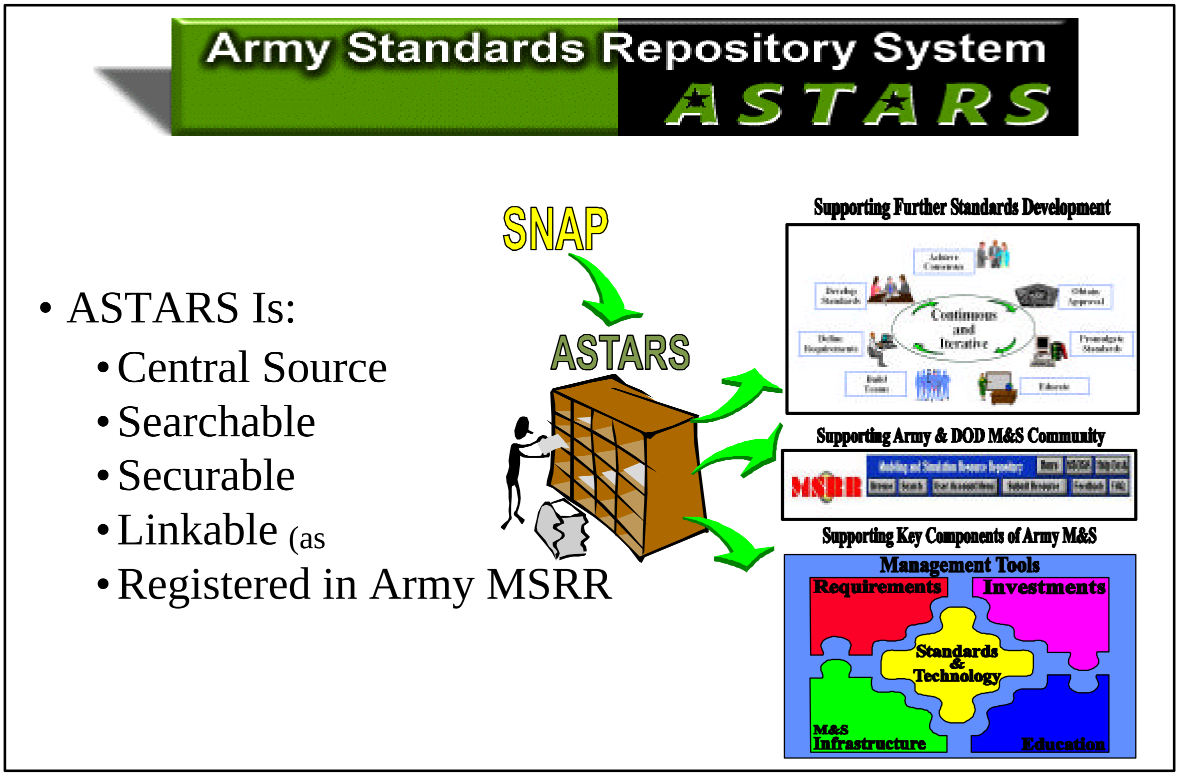

FIGURE 5. The Army Standards Repository System

When first entering ASTARS, a user has three ways to find the standard that they are interested in: View All, Browse, or Search. By selecting View All, the user is given a list of all standards, tools, and documents housed in ASTARS, regardless of their associated category. The standards title, a brief description, the category, and submission date are provided. By selecting Browse, the user is taken to ASTARS' Browse page. Here the user may select a specific Standards Category to look in. Again, a list of all standards associated with that category is listed. By selecting Search, the user is taken to ASTARS' Search Documents page. Here all of the standards, tools, and documents in ASTARS can be searched by title, description, keywords, submitter, file name (e.g., standard.doc or algorithm.ppt), or file type (i.e., .doc, .xls, or .ppt). But regardless of how a user locates a standard in ASTARS, to obtain further information or – provided that access to it is not limited – download the standard the user selects simply selects the document's title.

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 to minimize the use of proprietary or contractor-unique approaches. It is equally important to identify and adopt products from major simulation programs for incorporation into 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 address 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 attendees to comment on the project nominations. Based on feedback from the audience, comprised of the P&T WG, other SCCs, and team members, the SCCs will be able to incorporate useful information into their project proposals.

The workshop for FY00 will be held at the Army Center for Strategic Leadership, Collins Hall, Carlisle Barracks, PA, from 21-25 May. Updated information concerning the workshop can be obtained from the AMSO website (http://www.amso.army.mil).

APPENDIX A

Key Personnel and Information

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STANDARDS CATEGORY COORDINATORS

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APPENDIX B

Standards Category Definitions and Requirements

Standards Category Definitions and Requirements Chart

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.	• Develop standard representations of the four acquire processes (signature, transmission, discrimination, and search) required by combat models and simulations • Develop standard techniques for implementing the acquire process representations into combat models and simulations • Assure integration of standard category products with other categorization perception models into combat models and simulations • Assure that anticipated changes in representation capabilities and requirements for category products are communicated to the other standard categories
System Design and Architecture	Addresses standards for the structure, relationships, and design principles/guidelines of the components of virtual, constructive, and live simulation systems from the Advanced Concepts and Requirements (ACR), Research, Development and Acquisition (RDA), and Training, Exercise and Military Operations (TEMO) domains.	• Facilitate the interoperability (e.g., data distribution, interest management, time management, and model to model interaction) of all types of models and simulations. • Facilitate the reuse of modeling and simulation components within and between simulation systems. • Expose paradigms for design of the overall structure of different simulation systems. • Disseminate definitions of system design and architecture concepts and components.
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. • Facilitate use of standard attrition methodologies by the M&S community • Improve known weaknesses • Investigate the adequacy of current methodologies and replace where deficient

Standards Category Definitions and Requirements Chart

Categories	Definitions	Requirements
C4I Integration	The process that develops hardware, software and procedural standards to provide a seamless vision of the battlespace on C4I systems and surrogates by incorporating and integrating the environment, entitles 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.	• Define and achievable set candidate standards that are consistent with the current JTA-Army C4I and M&S Domain Architecture • Determine C4I requirements for Terrain, Object Management, CDM, C3 Systems, Data, Dynamic Environment, and FDB SSCs • Define and articulate attainable, adaptable, and scaleable standards according to Technical Reference Model for C4I M&S Interfaces • Prototype standards prior to implementation
Command Decision Modeling (CDM)	Procedure, practices, processes, techniques, data, and algorithms that model or simulate human or automated behavior that result in a perception, a decision, an action or reaction, or a plan.	• Advance the art of modeling decision making in SAFOR, CGF, and constructive simulations • Foster communication and identify gaps in community CDM research efforts • Develop a collective requirement document for CDM to identify product expectations • Examine mission-planning applications of CDM • Explore representation of the individual as an agent
Communication Systems	Encompasses the objects, algorithms, and techniques necessary to replicate friendly and enemy control, communications, and computer systems and processes.	• Define and design objective systems M&S representations • Coordinate common systems representations with other categories • Upgrade current M&S capabilities to replicate systems • Insure design will permit systems interface with other M&S in the constructive and virtual worlds • Insure HLA compliance is part of the development of new M&S communications models • Provide for data interchange of allow communications effects to play in combat models • Develop MOEs to identify key elements and validation tolerances for control, communications, and computer M&S • Insure the models are available to users

Standards Category Definitions and Requirements Chart

Categories	Definitions	Requirements
Cost Representation	Addresses Army standard cost definitions and the data, tools, algorithms, and techniques necessary to accurately and consistently prepare and portray cost and economic analyses for military operations, acquisitions, and modeling and simulation activities.	• Develop, document, and promote Army standard cost definition, data, tools, algorithms, and techniques necessary to accurately and consistently prepare and portray cost and economic analyses for military operations, acquisitions, and modeling and simulation activities • Standardize techniques for comparing costs of alternatives • Update the Army's principal publications containing cost standards and guidance, as necessary • Lead Army cost analysis initiatives in support of Simulation Based Acquisition • Interface with other Army M&S standards categories
Data	Encompasses all areas that increase information sharing effectiveness by establishing standardization of data elements, database construction, accessibility procedures, data maintenance and control.	• Promote Data Standards • Develop infrastructure • Develop standard data models • Automate existing databases • Expand Education
Deployment/ Redeployment	Addresses 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 • 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, and processes at various levels of resolution • Ensure commonality and linkages with mobilization, logistics, and warfight simulations
Dynamic Atmospheric Environments	Those objects, algorithms, data, and techniques required to replicate weather, weather effects, and impacts, backgrounds, acoustic and transport and dispersion of aerosols and battle by-products in models and simulations.	• Provide fundamental environmental data for M&S • Provide consistent data for environmental effects models • Provide standardized database for system performance analysis • Provide set of standard synthetic natural environments

Standards Category Definitions and Requirements Chart

<table>
<tr><th>Categories</th><th>Definitions</th><th>Requirements</th></tr>
<tr><td>Functional Description of the Battlespace</td><td>The process and the information products that describe Army functions, validated by the user, and stored in a standard way for the use and consistent understanding of simulation developers.</td><td>• Develop standard information templates for use by the Army user and simulation developer
• Develop a process that captures validated and traceable standard descriptions of the behaviors, components, and characteristics of the Army domain
• Develop policy and procedures for managing Army repository data, models, and algorithms for simulation developers and users through a seamless knowledge warehouse for current and future simulations and models
• Establish liaisons between major Army simulation programs and other Standard Categories to encourage use and updates
• Standardize a front end analysis methodology and tool for simulation development
• 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</td></tr>
<tr><td>Logistics</td><td>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.</td><td>Develop standards to support M&S for the following Combat Service Support functions (in priority order):
1. Class III (Bulk POL)
2. Class V (Ammo)
3. Class VII (Major End Items)
4. Class IX (Repair Parts)
5. Personnel
6. Class I (Food and water)
7. Maintenance
8. Medical
9. Services
10. Classes II (Gen. Supplies), III (Pkg) POL), and IV (Construction Material)
11. Finance
12. Stockage
13. Classes VI (Personal Demand) and X
14. Facilities</td></tr>
<tr><td>Mobilization/ Demobilization</td><td>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.</td><td>• Standardize algorithms, objects, and techniques for modeling mobilization
• Provide linkage of mobilization models and simulations to real time databases
• Ensure commonality with strategic deployment modeling objects and algorithms</td></tr>
</table>

Standards Category Definitions and Requirements Chart

Categories	Definitions	Requirements
Move	Encompasses the objects, algorithms, data, and techniques necessary to replicate activities that influence land force platform/ unit and personnel movement across the battlespace within a theater of operations. It also addresses mobility and countermobility as engineer functions, suppression (as a mobility degrader), formations, and dispersion.	• Land force platform and personnel movement • Mobility and countermobility as engineer functions • Suppression effects on movement • Dispersion and formations
Object Management	The process that develops abstract object classes that are: (1) consistent in their representation of object attributes/methods; (2) applicable to 90% of the M&S employing them; (3) accepted by the M&S community; and (4) interoperable at levels allowed by their model environment.	• Develop definitions of abstract object classes for Army use • Develop policy and procedures for managing Army objects • Form liaisons between major Army simulation programs and other standard categories to encourage use, updates, and expansion of object classes • Explore methods for gathering, sharing and storing meta data about objects
Semi-Automated Forces (SAF)	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 human operators and/or computer software.	• 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 • Minimize operator overhead for SAF • Ensure structures and data bases are modular and easily isolated • Provide consistent representations for battle field systems, and unit tactical/doctrinal behaviors in all SAFs • 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 geospatial information content, resolution and accuracy requirements for developmental models and simulations • Determine standards for correlated terrain databases • Determine standards for rapid terrain database generation • Determine standards for dynamic terrain features • Determine a consensus based data exchange standard • Encourage use of reuse repositories (SNAP, ASTARS, MSRR etc.) • Coordinate with other categories closely coupled with terrain

Standards Category Definitions and Requirements Chart

Categories	Definitions	Requirements
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 • Build verification and validation tools and guidelines • Make the above tools available to users • Develop measures of effectiveness to identify key elements and establish validation tolerances
Visualization	Addresses the representation of the physical environment which includes representation of combatants (vehicles, aircraft, personnel, ships, etc) in a dynamic environment (includes the concept of virtual and constructive entities in a live environment).	• Determine how Visualization relates to the other standards categories and to C4ISR • Define and articulate attainable, adaptable, and scalable standards • Implement standards

Standards Category Definitions and Requirements Chart

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APPENDIX C

Standard Category Coordinators' Annual Reports

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Annual Standards Category Report for FY00

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 standards for the four acquire processes required by combat simulations and models.
2. Developing standard techniques for implementing the acquire process representations into combat models and simulations.
3. Assuring integration of standard category acquire products with the other standard categories.
4. Assuring that anticipated changes in representation capabilities and requirements for category products are communicated to the other standards categories.

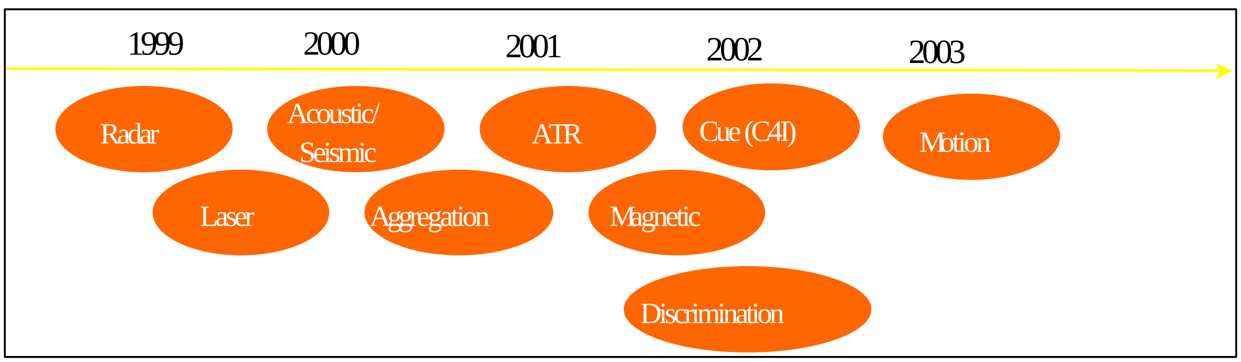
The crucial areas for acquisition model development fall in the areas pertaining to human-in-the-loop acquisition performance. Both the constructive simulation and virtual simulation environments have acquisition performance data and algorithms in common, therefore work on these topics has wide application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

ACCOMPLISHMENTS AND ASSESSMENT

The DELPHI vision model project was started in (FY97) as a project to extract and calibrate to US acquisition criteria the nonproprietary visual target acquisition algorithms of the BAE ORACLE vision model. Nonproprietary algorithms which duplicate the performance of the original ORACLE of the cone midget channel (stationary target/fovial vision) have been identified and the algorithms calibrated to several US field test data sets. A standard for the Delphi model is in development in the SC Acquire working group. Category Acquire has completed the actions on one standard and the **NVESD ACQUIRE** standard has completed the review and voting process and has been approved by the DUSA-OR as a standard. The **EOSAEL COMBIC** draft standard is in the senior review process and is expected to be through the voting process by the end of Sept. The standard algorithms for **VISUAL CONTRAST MODEL, TARGET ACQUISITION DRAW METHODOLOGY,** and **RADAR DETECTION MODEL** have been submitted to SNAP or will be shortly. Standards for visual target contrast propagation, thermal signature modeling and radar signature modeling are in the works but will not ready for submission to SNAP and ASTARS until FY00.

Some initial work has been done on the implementation methodologies for application of the high resolution Acquire standards in low resolution aggregated models such as WARSIM and JWARS.

PRIORITIES/ROADMAP



The road map for ACQUIRE remains largely unchanged:

1. The initial set of standards for optical and electro-optic (EO) sensors is about 75% complete. With the addition of a misidentification algorithm for EO sensors, the initial standards for EO sensors for each of the ACQUIRE processes will be complete. The completion of the DELPHI vision model standard, 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 in progress. This 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 priority of research and development submissions in the Acquire category is 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 FY00 have been assigned based on the following rationales:

1. 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.

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

3. 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.

Based on these criteria Standard Category Acquire is submitting one proposal for the second phase of the Acoustic Modeling for Army project and co-sponsoring a joint proposal with Standard Category Dynamic Atmospheric Environments for development of a standard on the atmospheric turbulence effects on target acquisition.

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Annual Standards Category Report for FY 00
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.

STANDARDIZATION REQUIREMENTS

The standardization objectives of the Attrition Category include the following:

1. Establish standard attrition methodologies for both high and low resolution modeling,
2. Facilitate use of standard attrition methodologies by the M&S community,
3. Improve known weaknesses, and
4. Investigate the adequacy of current methodologies and replace where deficient.

ACCOMPLISHMENTS AND ASSESSMENT

With the development of the Standards Nomination and Approval Process (SNAP) and the Army Standards Repository System (ASTARS), the Attrition Category placed eight standards nominations into SNAP for the purpose of formally adopting them as standards within the attrition community. Seven of these nominations were chapters from the Compendium of High Resolution Attrition Algorithms (published by the Attrition Category in October 1996) and represent the current state of the art methods of assessing attrition in high resolution models today. These address such attrition areas as direct and indirect fire hit and kill assessment, vulnerability and kill criteria, rate of aimed fire for direct fire weapons, and the modeling of air defense weapons as well as mines. The other standard nomination covers direct fire at the aggregate (low resolution) level. None of these have been formally placed in ASTARS. Each has reached the voting stage in the SNAP process and all are expected to become standards later this year.

Another important theme within the category this year was the continuation of support to two simulations being developed for the Army – Joint Warfare System (JWARS) and Warfighters' Simulation (WARSIM) 2000. As in the past, the use of standard algorithms/approaches was recommended, along with modifications to accommodate requirements for particular applications. For indirect fire modeling, the ARTQUIK (conventional artillery) and SMART (smart munitions) models were recommended for use in both JWARS and WARSIM 2000. Documentation and code were provided to each of the model developers. Meetings were held with representatives for JWARS and WARSIM 2000 to address issues pertaining to their different model requirements. As a result, the current implementations of these indirect fire methodologies within those models are largely based on standard approaches.

In connection with the JWARS direct fire attrition approach, several issues regarding its adequacy and theoretical soundness were raised by Dr. James Taylor of the Naval Postgraduate School. A large meeting involving category members and other interested analysts (from AMSAA, ARL, TRAC-FLVN, CAA, DSCOPS, JWARS Program Office, Marine Corps CDC, Naval Postgraduate School) was convened in December 1998 to discuss all the critical issues identified by Dr. Taylor. After much lively discussion and excellent cooperation among the participants, all attendees agreed that the Army's recommended approach was still the best option for use in assessing direct fire attrition in JWARS. It was further agreed that research into participation rates and such related areas as acquisition modeling should be done for possible future refinements to the approach. (At the May 1999 Standards Workshop, the Acquire SCC identified aggregate level acquisition modeling as one of the priority areas for his group over the next few years.) As this report is being written, the JWARS attrition approach is again under scrutiny and another round of meetings is being held to discuss certain issues/questions. It is too early to determine what the results of this latest look at direct fire attrition will be and what impact, if any, there might be on JWARS attrition modeling.

Apart from the provision of indirect fire methodologies mentioned earlier, support by the category to the WARSIM 2000 program has taken the form of a series of methodology reviews. In addition to the area of indirect fire attrition, methodologies for direct fire, air defense, and mines were also carefully reviewed. All comments and suggested changes were coordinated with the WARSIM Project Manager's Office, STRICOM, NSC, and the contractor developers. An important agreement reached at a January 1999 meeting at STRICOM called for the development of an alternative attrition method for the purpose of mitigating the risk associated with the current WARSIM attrition approach. However, the lack of funding has been a limiting factor for development of an alternative this year.

The category has also been working on the Aggregate Level Attrition Compendium as part of an AMIP-funded task. It is viewed as the companion to the High Resolution Attrition Compendium published in 1996. It will be a very important volume in terms of documenting available aggregate attrition methods within the Army. Virtually all areas of aggregate level attrition are being addressed within this document, including direct fire (ground-to-ground, ground-to-air, air-to-ground, air-to-air), indirect fire, and minefield attrition. Progress to date has been confined mainly to the ground-to-ground direct fire aspects. The first draft is still anticipated to be available in September 1999, while the compendium is expected to be published during the second quarter of FY 00.

PRIORITIES FOR NEXT YEAR

Strong emphasis will again be placed on the use of existing attrition standards and the development of new ones. As the standards nominations currently in SNAP are approved and placed into ASTARS, the high resolution modeling portion of the category's first requirement (see earlier page) will largely be accomplished. Significant work remains to be accomplished on the low resolution modeling portion, however. The work on the Aggregate Level Attrition Compendium will do much to address that need. In addition, the new compendium will address the category's second requirement of facilitating the use of standard attrition methodologies by the M&S community. Therefore, the completion of that document will receive high priority.

Because of their importance to the analytical and training communities within the Army, the JWARS and WARSIM 2000 models will continue to receive support from the Attrition Category as required. While the implementations of modified standard approaches are further developed and tested, category representatives will review and analyze results and recommend additional refinements as requested by the respective program offices. It is anticipated that sensitivity analyses will become increasingly important for these models as functionality checks are made over the next year. Also, work on a stochastic version of the rate-based aggregate kill methodology will be emphasized for risk mitigation purposes and as a viable alternative to the current WARSIM 2000 attrition approach.

Another top priority for the coming year will be the development of alternative vulnerability metrics for high resolution combat models. This work addresses the third and fourth requirements for the category –to improve known weaknesses and check the adequacy of current methodologies. An expanded set of kill types along with a practical set of degraded states for target classes needs to be defined and developed to support Combat XXI and OneSAF initiatives, the WARSIM 2000 model, and analyses of new Army systems with increased C4I capabilities. Work in this arena needs to begin now so that critical model developments and system analyses can be accomplished in a timely manner.

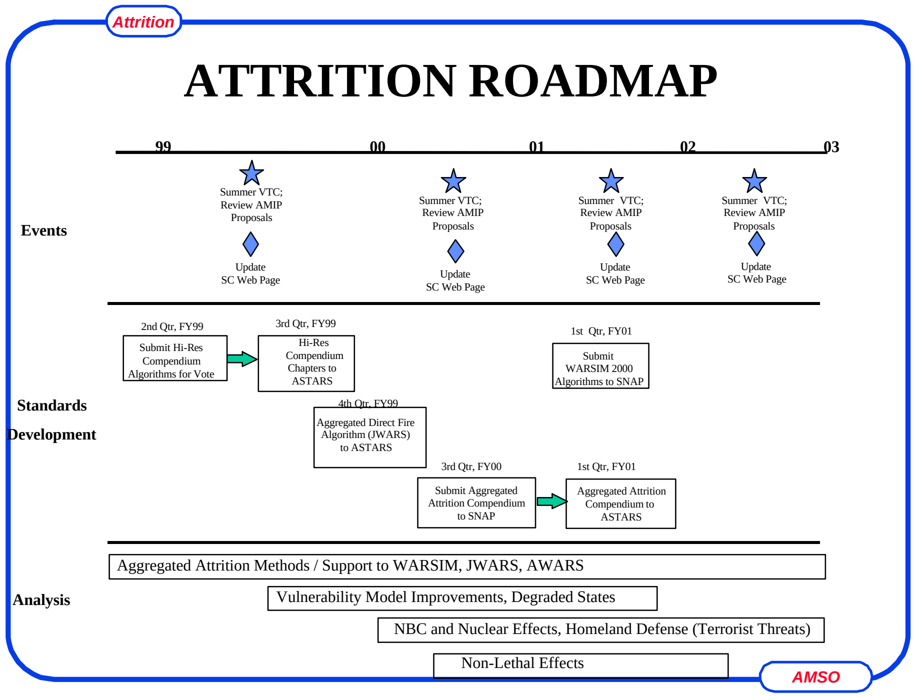
As shown in the Category Roadmap below, other efforts in the category will include investigating methodologies and developing standard approaches for NBC and nuclear effects and the attrition aspects with respect to Homeland Defense.

ROADMAP

The roadmap below reflects the priorities already discussed. The emphasis on aggregate attrition is shown as it is the top block of the analysis portion of the chart below. AMSAA, CAA and TRAC-FLVN are combining their efforts to produce the Aggregate Level Attrition Compendium, which is an AMIP-funded project for FY 99.

The second block of the analysis portion will involve the efforts of ARL, TRAC-WSMR and AMSAA to define new vulnerability metrics and test them in high resolution scenarios using the GROUNDWARS and CASTFOREM models.

For the third block in the analysis portion of the chart below, USANCA efforts will be enlisted to identify current methodologies as potential standard approaches for modeling NBC and nuclear effects and suggest how to employ them in conjunction with other standard attrition methods in Army M&S.


Attrition
ATTRITION ROADMAP
99
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02
03
Events
Summer VTC; Review AMIP Proposals
Update SC Web Page
Standards Development
2nd Qtr, FY99
Submit Hi-Res Compendium Algorithms for Vote
3rd Qtr, FY99
Hi-Res Compendium Chapters to ASTARS
4th Qtr, FY99
Aggregated Direct Fire Algorithm (JWARS) to ASTARS
1st Qtr, FY01
Submit WARSIM 2000 Algorithms to SNAP
3rd Qtr, FY00
Submit Aggregated Attrition Compendium to SNAP
1st Qtr, FY01
Aggregated Attrition Compendium to ASTARS
Analysis
Aggregated Attrition Methods / Support to WARSIM, JWARS, AWARS
Vulnerability Model Improvements, Degraded States
NBC and Nuclear Effects, Homeland Defense (Terrorist Threats)
Non-Lethal Effects
AMSO

Annual Standards Category Report for FY00

C4I INTEGRATION

STANDARDS CATEGORY DEFINITION

The process that develops hardware, software and procedural standards to provide a seamless vision of the battlespace on C4I systems and surrogates 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.

STANDARDIZATION REQUIREMENTS

C4I Integration embraces interfaces to command, control, communications, computers, and intelligence (C4I) devices, data models, fielding plans, graphical user interfaces (GUIs), icon attributes, and the military decision making process. Models and simulations stimulate, and are stimulated by, C4I in all three M&S domains. Establishing standards ensures M&S software and hardware are interoperable and synchronized with C4I software and hardware. Standards make potentially diverse and complex requirements manageable and 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. C4I Integration requirements summarized:

1. Define an achievable set of candidate standards that are consistent with the current JTA-Army C4I and M&S Domain Architectures.
2. Determine C4I requirements for Terrain, Object Management, CDM, C3 Systems, Data, Dynamic Environment, and FDB SCCs.
3. Define and articulate attainable, adaptable, and scalable standards according to the Technical Reference Model for C4I M&S Interfaces.
4. Prototype standards prior to implementation.

C4I Integration's main effort is closely providing a feasible and cost effective means to interoperate, both in the short term and the long term. Both models and simulations, and C4I ultimately must portray situational information for decision makers. C4I integration focus is to forge common standards for not only the M&S community, but also the C4I community. Standards developed will not only promote reuse and interoperability, but also steer developers to engineering software designed to support the broad range of simulation and C4I interoperability requirements – event and architecture planning, data alignment, stimulation, data collection, analysis, course of action analysis, and mission rehearsal.

ACCOMPLISHMENTS AND ASSESSMENT

In its second year, the category underwent a name change from Visualization to C4I Integration, to better reflect the concentration on interoperability. The category has been very active and has had exceptional participation from Army Components.

Much has changed in the Army that is leading to a positive assessment for the coming years. STRICOM stood up a program manager for C4I System Stimulation (C4ISS) and TRADOC has designated a TRADOC Program Office (TPO) for C4ISS. There is now close coordination within the C4I Integration Standards Category with the C4I Community represented by DISC4, ADO, PEO-C3S and the CTSF.

Following the establishment of the C4ISS Program, the Army Executive Steering Council (AMSEC) asked the C4ISS to chair an Overarching Integrated Project Team (OIPT) to recommend C4I to M&S Integration Policy and Strategy.

There are several initiatives that are focusing on Architectures and Models (both Data and Object-Oriented):

AMSO is cooperating with DMSO on a project to develop a reference C4I Joint Common Data Base Federation Object Model (AMSO/DMSO C4I Project). This project involves the EAGLE simulation from TRAC, the WARSIM simulation from STRICOM, the JCDB project from PEO-C3S and a C4I Interface, the Tactical Simulation Interface Unit (TSIU).

DISC4 is leading an initiative to work with the Object Management Standards Category and the C4I Integration Standards Category to investigate how Data Models and Object Models can be aligned and recommend a strategy for coordinated future model development.

The Army (AMSO) is chairing a DII COE Advisory Group to investigate how M&S should be integrated into the DII COE. This will report back to the Army Configuration Management Board (ACMB) and the DII COE Architecture Oversight Group (AOG).

The results from this category are of four types: meetings, technical papers, AMIP/SIMTECH proposals and projects, and standards.

1) Meetings:

Ft. Leavenworth, August 1998

Event Control/AAR/Data Collection Standards

Simulation Interoperability Workshop, September 1998

Initialization and Data Standardization

Ft. Hood, January 1999

C4I Interface Information Exchange

Simulation Interoperability Workshop, March 1999

Terrain

Value Engineering Workshop, April 1999

Policy, Requirements, Standards

Value Engineering Workshop, June 1999

Terrain

Ft. Hood, July 1999

C4I Interface Information Exchange

Planned C4I Integration Meetings:

Simulation Interoperability Workshop, September 1999

JCDB/CMP Update, Alignment

Ft. Hood, January 2000

C4I Interface Information Exchange

Simulation Interoperability Workshop, March 2000

Terrain, BML/JCDB

Papers

Hieb & Staver, 1998, *The Army's Approach to Modeling and Simulation Standard For C4I Interfaces*, Paper 98F-SIW-259, 1998 Fall Simulation Interoperability Workshop.

Hieb & Blalock, 1999, *Data Alignment Between Army C4I Databases and Army Simulations*, Paper 98F-SIW-34, 1999 Spring Simulation Interoperability Workshop.

Timian, Hieb, Glass & Staver, 1999, *Using Standard Components to Interface to Simulations*, Paper 98F-SIW-35, 1999 Spring Simulation Interoperability Workshop.

Hieb & Timian, 1999, Using Army Force-on-Force Simulations to Stimulate C4I Systems for Testing and Experimentation, 1999 Command and Control Research and Technology Symposium (OSD).

Ressler, Hieb & Sudnikovich, 1999, *C4I and M&S Interoperability Reference Model*, 1999 Fall Simulation Interoperability Workshop, to appear.

Two of the papers from the Spring 99 SIW were on the recommended reading list, showing a growing interest in interoperability in the M&S community.

AMIP/SIMTECH Proposals and Projects

There were both AMIP and SIMTECH projects that were approved in 1998 that were in the C4I Integration Standards Category.

The AMIP project resulted in four SISO papers:

Hieb & Blalock, 1999, *Data Alignment Between Army C4I Databases and Army Simulations*, Paper 98F-SIW-34, 1999 Spring Simulation Interoperability Workshop.

Timian, Hieb, Glass & Staver, 1999, *Using Standard Components to Interface to Simulations*, Paper 98F-SIW-35, 1999 Spring Simulation Interoperability Workshop.

Hieb & Timian, 1999, Using Army Force-on-Force Simulations to Stimulate C4I Systems for Testing and Experimentation, 1999 Command and Control Research and Technology Symposium (OSD).

Ressler, Hieb & Sudnikovich, 1999, *C4I and M&S Interoperability Reference Model*, 1999 Fall Simulation Interoperability Workshop, to appear.

The STRICOM SIMTECH project under DISC4 resulted in a DII COE Message Processor (CMP) API for simulation.

The NSC SIMTECH project under TRADOC resulted in a preliminary JCDB FOM and analysis of the possible ways to interface to the JCDB.

Standards

The Command and Control Simulation Interface Language (CCSIL) Standard was approved as an interim standard in June, 1999.

PRIORITIES FOR FUTURE WORK

The first priority is to develop common standards and methodologies for M&S and C4I that enable data exchange without costly and timely integration efforts. The DII COE and HLA have the potential, if carefully considered, to create the conditions for developers to forward engineer interface capabilities rather than do post engineering after M&S or C4I systems are developed. In FY 00, the C4I Integration Team will continue to develop a vision and a migration plan for attaining that vision.. The data passed between M&S and C4I is extensive so a “divide and conquer” approach is being taken that classifies information according to the C4I Interface Model shown above in Figure 1. Exercise Control is defined as that data that must be exchanged to Start, Stop, Resume, Restore to an earlier state, manage time, manipulate ground truth, and collect data for AAR and analysis. Non-Persistent data is defined as data that presents the dynamic status of the synthetic or live environment such as task organization, orders, reports, tracks, and effects. Persistent data is defined as that information that is static or nearly static such as MTOE, OPLAN, equipment characteristics, terrain, and weather. Persistent data is associated with the database build process and non-persistent is germane to stimulation and emulation.

A continuing priority is to bring the C4I development community and the M&S community into better understanding of each other’s requirements and designs. This will be accomplished by technical exchange meeting every six months at the CTSF in Fort Hood.

Common standards, common components and common models (representations and algorithms) touch several categories, namely Data, Terrain, Architecture and Dynamic Environment, and require close coordination with the respective SCCs as is currently occurring with the Data/Object Model alignment initiative.

ROADMAP

The C4I Integration Roadmap characterizes the technical milestones for integrating models

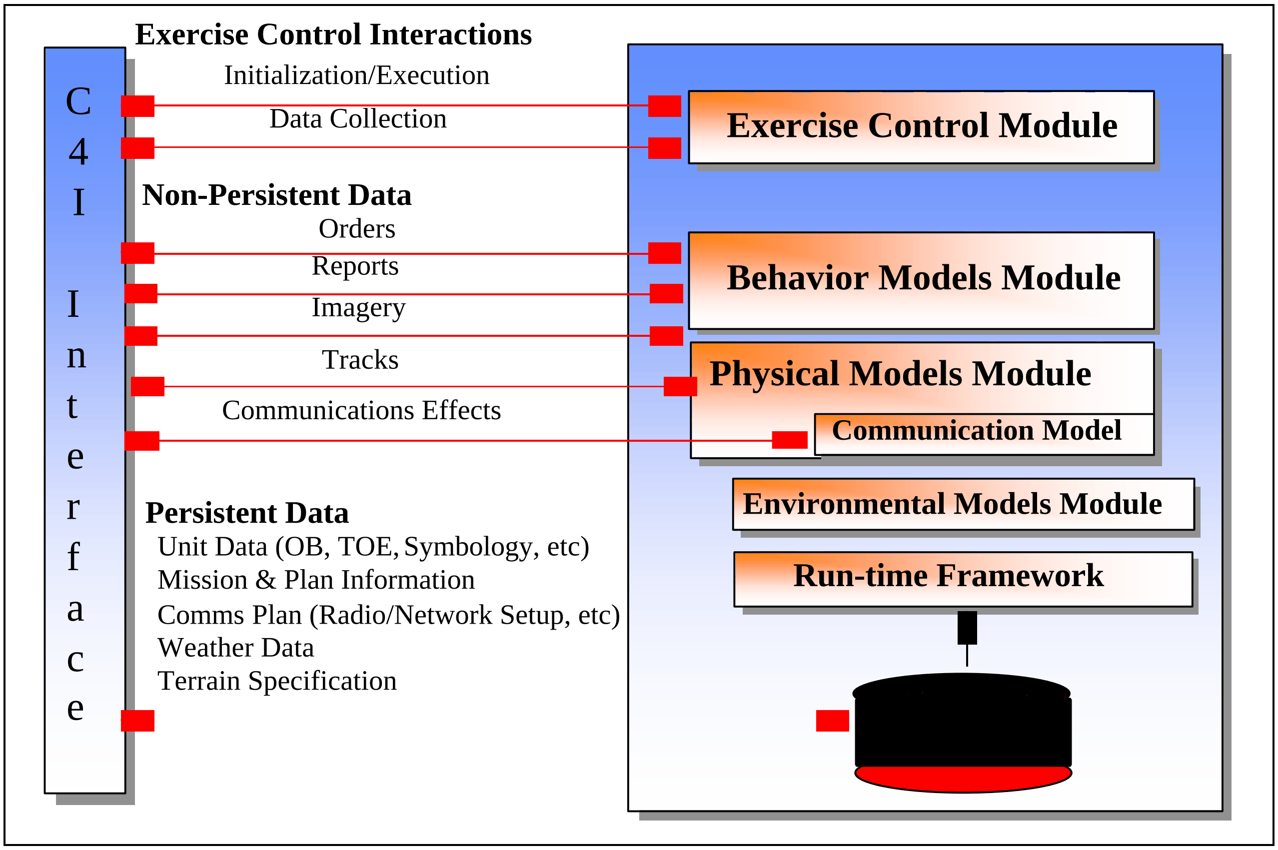


Figure 1: C4I Interface Reference Model

and simulation, C4I, and for integrating the synthetic environment with the digitized battlefield. Current legacy systems lack common standards for interoperability and reuse. Integration is currently characterized by:

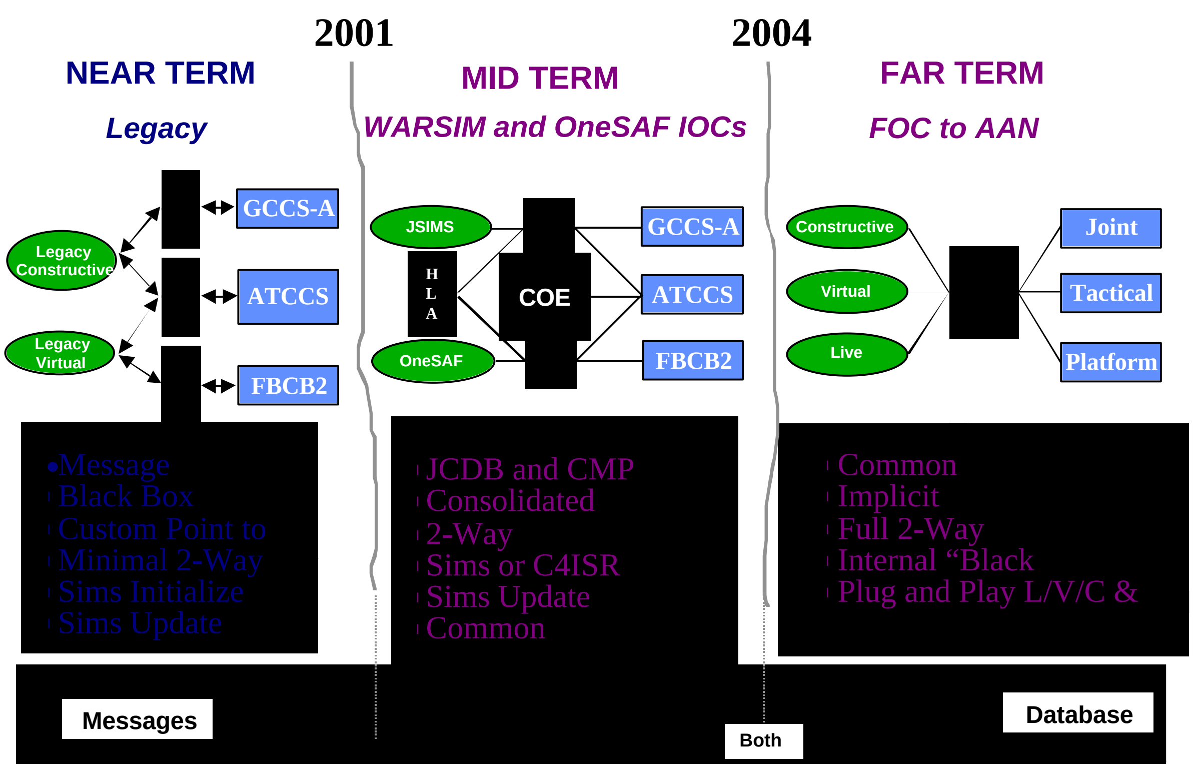


Figure 2: C4I Integration Standards Category Roadmap

- Message translation of formats that vary by echelon and battlefield functional area.
- Custom black box linkage that must continually be modified end to end to support M&S application software.
- Minimal 2-way feeds from C4I systems to M&S. Only AFATDS inputs orders to the synthetic environment in place of the workstation.
- Analog production of databases that mirror M&S to C4I that is both costly and time consuming. Once database continuity is established, M&S initialize C4I systems providing location. Analog procedures are then used to provide C4I systems unit status and disposition.
- During runtime, the simulation stimulates C4I systems with friendly and enemy location, and in some cases, unit status.

C4I systems and M&S currently under development are required to comply with Joint Technical Architecture (JTA). For M&S, the JTA standard is the High Level Architecture (HLA), and for C4I, the standard is the DIICOE. In the mid term, integration is characterized by:

- C4I systems beginning to use distributed databases to reduce message traffic and bandwidth requirements.

- Black box linkage that includes not only middle-wear interfaces but also the C4I DII COE Components such as the JCDB and the CMP which will serve as a single point entries for ABCS stimulation.
- 2-way interactions capitalizing on intelligent agents in M&S that enable C4I systems to more fully serve as synthetic environment workstations to do exercise control, after action review, and data sharing versus mirroring.
- Initialization by C4I systems to further reduces scenario and database development overhead. This also enables course of action analysis and rehearsals by downloading persistent information such as task organization, STARTEX disposition, and equipment.
- Simulations continue to update C4I with dynamic position and strength information.
- Standards common to M&S and C4I enable interfaces to exchange less application data and more common data reducing data exchange volume and types. Common standards continue to allow freedom of action for M&S and C4I systems.

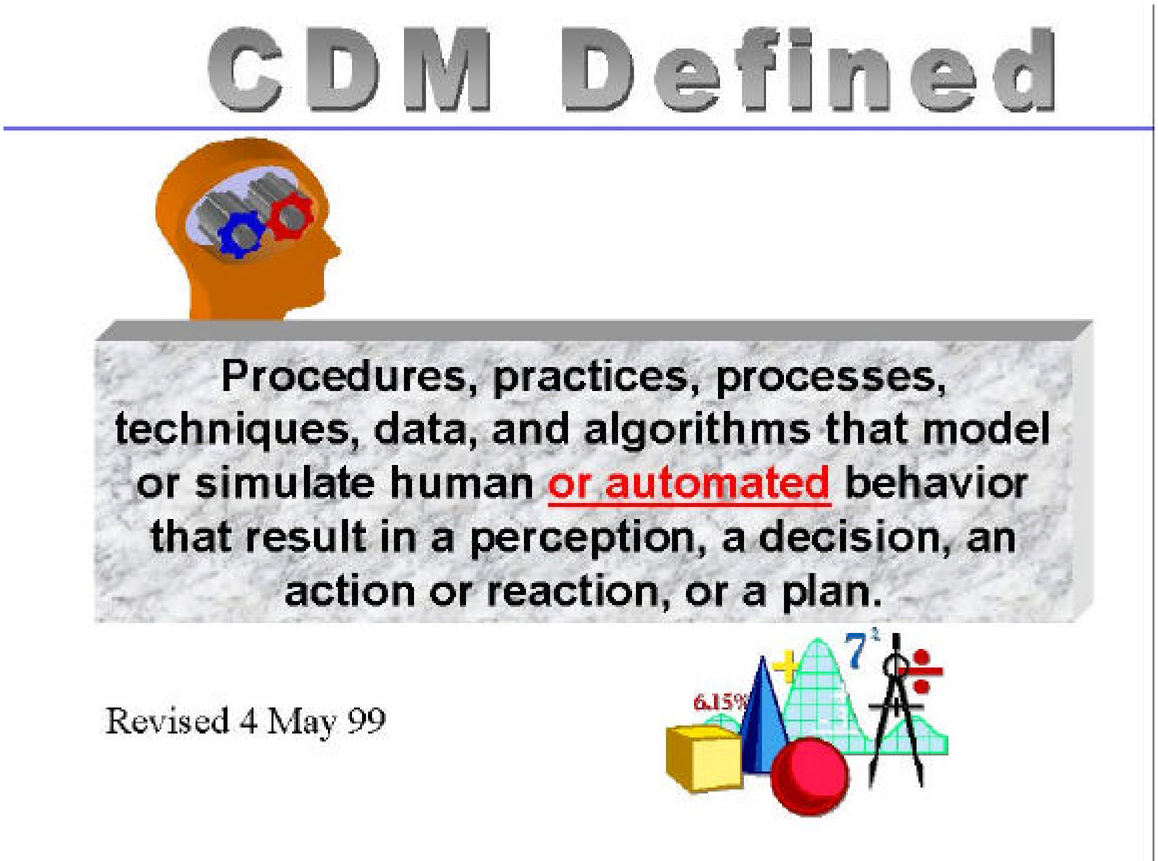
The far term forecast for C4I systems is to exploit the synthetic environment capabilities in the information age:

- Database exchange among and between C4I and M&S will nearly eliminate message traffic.
- Common standards will lead to a common architecture at the operational, systems, and technical levels for ACR, RDA, and TEMO.
- Full 2-way interaction including speech recognition and fully interactive battlefield visualization tools will make C4I systems indistinguishable from the synthetic environment.
- Interfaces with common standards will persist continuing to bridge the live environment from the synthetic environment, however, there will no longer be separate black boxes, rather imbedded software either in C4I or M&S.

Annual Standards Category Report for FY00

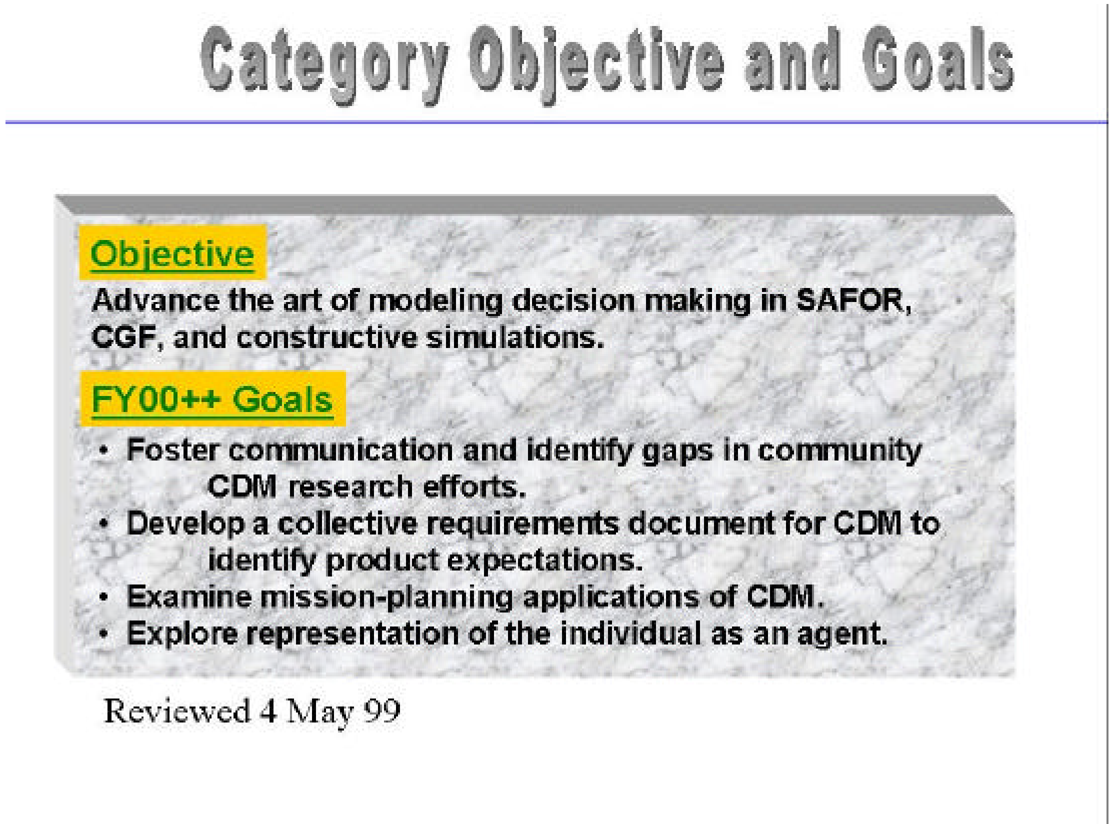
COMMAND DECISION MODELING (CDM)

STANDARDS CATEGORY DEFINITION



Those in attendance at the May workshop agreed to add the words "or automated" to the definition. The intent of this addition is to capture the man-made computer behaviors in present and future automated decision aids which automate situational assessment, planning and control. Intelligent agents will assist the commander and staff by providing first order perceptions that would have been accomplished by human in the loop processes.

STANDARDS REQUIREMENTS



FY99 ACCOMPLISHMENTS AND ASSESSMENT

a. BATTLE MANAGEMENT LANGUAGE AND KNOWLEDGE REPRESENTATION

STANDARD

This year we were able to produce our first approved standard which was well received by the M&S community. The BML standard was approved in May 99 and is available for use within ASTARS.

What is a Battle Management Language?

A battle management language or BML is the verbiage or vocabulary that simulation programmers and simulation workstation controllers use to tell the computer how to plan and automate military functions or perform unit military functions currently performed by human controllers (man to machine). This type of language allows the computer to communicate internally and with other computers using a standard language (machine to machine). Finally the BML allows the computer to provide programmers and controllers military reports and information in a standard manner (machine to man). Simulations programmed to execute Command Decision Modeling (CDM) use a BML to allow “Intelligent Agents or “Handlers” created by programmers to interface with the human controller.

Military doctrine is a body of fundamental principles by which the military forces or elements guide their actions in support of national objectives. It is authoritative but requires judgment in application.

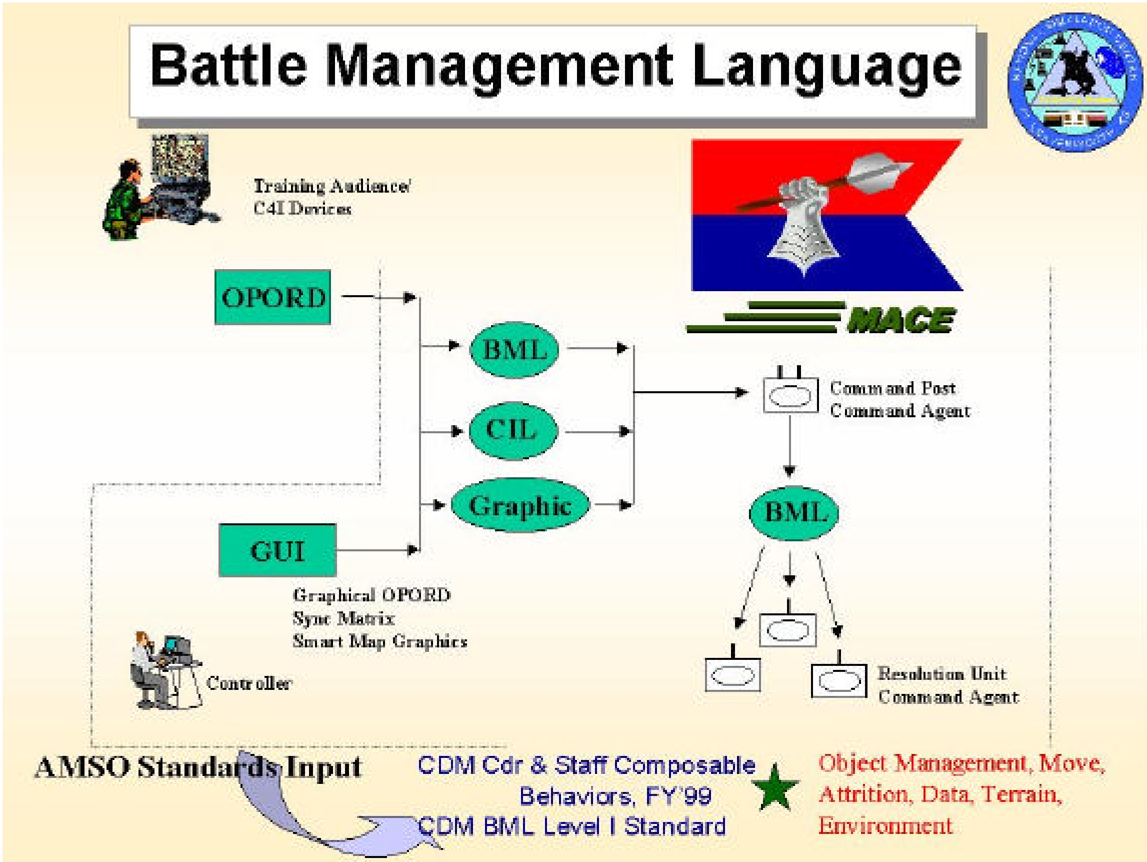
Doctrinal language is a set of terms and verbiage that describes or defines military doctrine. In order to make a viable interface between man and computer in military simulations, Battle Management Languages must be in the same doctrinal language spoken and written by military users.

MITRE Corporation with its CCSIL project and TRAC with its Eagle Simulation language have already established doctrinal language as a model and simulation standard. Both adjust the doctrinal terms to match their specific simulation needs for clarity and brevity. The Battle Management Language Standard proposed below is more general to support all simulations from individual soldier to Corps level.

Using BMLs in Programming Simulations

Programmers must take several key points into consideration as they use BMLs in models and simulations. First, because of current efforts to reduce simulation controllers, at some point in military simulations there will have to be a man-machine interface where a computer must automatically assimilate a man created written or oral order as input to interact with CDM processes to provide orders for subordinate units. Second, for at least the next ten years there will be a mix of analog and digital higher headquarters orders which increases the complexity of the BML problem. Third, when a model contains CDM capability, it must also contain the computer processes to assimilate digitized higher headquarters orders in a form that operates with the programmed CDM capability. Fourth, since the CDM capability must operate in conjunction with a higher headquarter order, the BML must be in the same doctrinal terms that the higher headquarters order is in.

There are at least three different situations in which CDM processes require doctrinal BML inputs to produce doctrinal outputs. First, the higher headquarters and subordinates are conducting an operation and are planning a subsequent operation that requires a complete new order for each level of command. Second, the higher headquarters and subordinates are conducting an operation and a small adjustment in the current plan requires a fragmentary order for each level of command. Third, a real or automated commander perceives a battlefield situation that requires his decision and a directive to execute to a real or automated staff element or subordinate unit and reports to a human controller.



The above figure graphically depicts how BML is utilized by the user or operator to communicate with a simulation. Extensions to this language will be developed as part of next year's efforts. These extensions will examine how to convey commander's intent to the simulation (Commander's Intent Language (CIL)) and how to develop a graphical language for passing situational drawings and operational overlays to the simulation.

What is the Doctrinal Basis of this BML?

The BML standard displayed below is based on the US Army and US Marine Corps manual for doctrinal terms FM-101-5-1/MCRP 5-2A, Operational Terms and Graphics, US Army FM 101-5 Staff Organizations and Operations and US Army FM100-40 (DRAFT) Tactics. FM-101-5-1/MCRP 5-2A includes NATO standard terms and a number of air and naval terms. Making the BML doctrinally correct will increase its usefulness for military programmers to understand and improve the efficiency of changing object-oriented code to a well-known military standard. It also relieves military users from learning a completely new language to operate their training simulations. The next step in improving the BML Standard is to reference all Air Force and Navy doctrinal terms to make the standard fully joint.

FM-101-5-1/MCRP 5-2A, Operational Terms and Graphics is a robust dictionary of military terms. We have tried to reduce the number of doctrinal terms in our BML to the seminal number required in order to reduce the magnitude of the problem and to conserve computing space for developers.

What are the key factors required for units to reason in a Simulation?

When programmers write the rules, procedures and methods for units to reason within simulations, they must consider five key factors to allow automated units to analyze their situation, project the end state of the operation, determine a course of action and execute the course of action. The key factors are identification of the unit (who), the type of operation and task the unit is to do (what), the time the operation will take place (when), where the operation will take place (where) and the purpose the unit is performing the operation (why).

The Who, What, When, and Where factors are the science aspect of battle. They are precise things that can be clearly stated, measured or counted. The Why factor is the art aspect of battle. It is written less in doctrinal terms and more in brief, concise English explaining the operation's desired effect or result. The Why factor does not lend itself to representation by a BML as easily as the Who, What, When, Where factors.

Other factors which contribute to who, what, when, where, why are command relationships, formations and general terms. Command relationships describe the degree of control and responsibility a commander has over his forces. Formations are ordered arrangements of forces for specific purposes. General terms don't fall into any of the specific categories but support all the other categories.

Who - Unit name - A distinct name for each unit in the database. Examples are B/1-22INF, 2-68AR, 1/3/C/1-39INF.

What - Type of operation - A broad category of tactical activities, each with specific doctrinal tenets. Examples are attack, defend, movement to contact. **Task –** Tasks are the results that the operation should accomplish. Examples are cover, defeat, destroy, secure.

When - Time - The second, minute or hour an event will or does take place. Examples are 150800Z Nov 98, D-day, BMCT.

Where - Location - A line, point, place or area that a unit must go to or report crossing/reaching. Examples are objective, phase line, grid location, latitude/longitude location or battle position.

Why – Why is the purpose of an operation. Examples are: prevent the enemy from using avenue of approach one, or allow TF 1-22 to move along Route Whiskey to PL Cat unobserved.

How would a BML work in a CDM Environment?

A digitized unit, training in a field environment, would prepare an n order using the military decision-making process (MDMP). The unit would transmit the message to its subordinates via its command and control systems. In this example a simulation automates the subordinates in a simulation miles away at a simulation center. One human controller monitors all the subordinates in a brigade size unit.

The automated subordinates receive the higher order and follow their automated decision process using the BML. First, they analyze the higher order with key word and graphics search programs to determine the who, what, when, and where requirements of the higher headquarters. Paragraphs two and three will provide the specified tasks for the subordinate unit. Rules sets can allow analysis to deduce implied tasks.

Next they assess their current perceived situation, the perceived enemy situation and the perceived terrain situation. Based on these perceptions, the unit's project what the situation will be when the new operation starts and use their programmed methodologies to establish their plan including graphics and formations.

The human controller can check the automated plans and "tweak" them or leave them as planned. The computer stores the plan and associated MDMP for AAR purposes. The computer will also keep track of perceived versus real truth for AAR purposes. The controller has access to slide bar features that can vary the automated units' fatigue factor, training level and morale.

Examples of BML from the User's Guide

The User's Guide, **Battle Management Language** provides detailed doctrinal BML in alphabetical order organized by Unit **Name, Type of Operation, Task, Location, Time, Command Relationships, Formations and General**.

Unit Names (Who) (To Be Developed)

Unit names must conform to the provisions of Chapter 4, FM-101-5-1/MCRP 5-2A, Operational Terms and Graphics so that the simulation can read electronic unit orders and unit graphics to understand the unit names. That also means that simulations will have to track units by their actual names or with a name interface system. Chapter 4 requires unit icons to have a unique title of 21 or less alphanumerics on the left side of the icon and a higher formation number or title on the icon's right side.

Examples of Types of Operations (What) from FM101-5/MCRP 5-2A

Attack (s, ed, to attack) - A form of offensive operation characterized by coordinated movement supported by fire. It may be designated as a main or a supporting attack. The principal attack options include hasty attack, deliberate attack, spoiling attack, counterattack, raid, feint, and demonstration.

Movement to contact (move to contact) - A form of the offense designed to develop the situation and to establish or regain contact

Examples of Tasks (What) from FM101-5/MCRP 5-2A

Clear (s, ed, to clear) - A tactical task to remove all enemy forces and eliminate organized resistance in an assigned zone, area or location by destroying, capturing or forcing the withdrawal of enemy forces such that they cannot interfere with the friendly unit's ability to accomplish its mission.

Defeat (s, ed, to defeat) - A tactical task to either disrupt or nullify the enemy force commander's plan and subdue his will to fight so that he is unwilling or unable to further pursue his adopted course of action and yields to the will of his opponent.

Examples of Location (Where) from FM101- 5/MCRP 5-2A

Objective (s) -The physical object of the action taken, e.g., a definite tactical feature, the seizure and/or holding of which is essential to the commander's plan.

Phase Line (s) - A line used for control and coordination of military operations, usually a terrain feature extending across the zone of action.

Examples of Time (When)

060500 Aug 98 - 5AM on 6 August 1998. The first two numbers are the date, the next four numbers are the time based on a twenty-four hour clock and the month and year are self-explanatory.

Begin morning civil twilight (BMCT) - Begins when the sun is halfway between beginning morning and nautical twilight and sunrise, when there is enough light to see objects clearly with the unaided eye. At this time, light intensification devices are no longer effective, and the sun is six degrees below the eastern horizon.

Examples of Command Relationships from FM101-5/MCRP 5-2A

Attach (es, ed, to attach) - 1. The placement of units or personnel in an organization where such placement is relatively temporary. **2.** The detailing of individuals to specific functions where such functions are secondary or relatively temporary, e.g., attached for quarters and rations; attached for flying duty. (Army) — Subject to limitations imposed by the attachment order, the commander of the formation, unit, or organization receiving the attachment has the responsibility to provide the attached units with sustainment support above its organic capability. However, the responsibility for transfer, promotion of personnel, nonjudicial punishment, courts martial, and administrative actions, such as SIDPERS transactions and unit strength reporting, are normally retained by the parent formation, unit, or organization. (See also assign, operational command (OPCOM), operational control (OPCON), and organic.) See FM 101-5.

Direct Support - A mission requiring a force to support another specific force and authorizing it to answer directly the supported force's request for assistance. (NATO) — The support provided by a unit or formation not attached to, nor under command of, the supported unit or formation, but required to give priority to the support required by that unit or formation. (See also general support (GS), general support reinforcing (GSR), and reinforcing (R).) See FMs 6-20, 7-30, 71-100, 71-123, and 100-15.

Examples of Formations from FM101-5/MCRP 5-2A

Line Formation - An arrangement of vehicles or personnel in which elements are arranged abreast of each other. This formation permits maximum fire to front or rear and a minimum of fire to the flanks. (See also formation, movement formation, echelon formation, and column formation.) See FMs 1-112, 7-7, 7-8, 7-10, 7-20, 7-30, 17-15, 17-95, and 71-123.

Wedge Formation - A unit formation with subordinate elements in a V formation with the point toward the suspected or templated enemy positions. This facilitates control and transition to the assault (line formation). The wedge provides maximum firepower forward and good firepower to the flanks. (See also vee formation and formation.) See FMs 7-7, 7-8 and 7-20.

Examples of General Terms from FM101-5/MCRP 5-2A

Priority of Fires - The organization and employment of fire support means according to the importance of the supported unit's missions.

Main Effort - The unit, battle position, sector, zone, axis, avenue of approach, area of operations, theater of operations, and so forth, the senior commander has determined has the most important task and purpose at that time, whose success will make the most difference in the accomplishment of the higher commander's overall mission or objective.

b. COMPOSABLE BEHAVIOR REPRESENTATION

Accomplishments: The researchers on the Composable Behavior Representation project have gathered and analyzed the doctrinal materials that describe the Army's command and control processes to be represented (i.e. FM101-5, FM 101-5-1, Operational Architecture) as well as supporting documents such as WARSIM 2000 Knowledge Acquisition papers and CGSC instructional materials. We have become familiar with the contents of the Operational Architecture (OA) and with BPWIN, the software tool used to explore the OA. We have laid out key OA diagrams showing the key commander and staff command and control functions at echelons from division to platoon and examined the processes at each level for similarities, differences and missing doctrinal materials. We have developed reports and databases describing the inputs, outputs, required resources and so on associated with the C2 processes at each echelon. We have identified doctrinal processes that are important to the simulation world.

Lessons learned: Information learned during the execution of the project that was not described in the implementation plan but would be beneficial to others.

- To develop efficient inheritance paths, you may have to start at the lowest level (perhaps squad or platoon) and build up to higher echelons (i.e., brigade) adding complexity rather than starting a higher levels and building down reducing complexity.
- There may be another way of looking at composing behaviors besides the paradigm of combining lower behaviors/processes to form higher behaviors/processes. An alternate approach may be to consider the top level process and all of its potential inputs from squad to brigade or higher in the same way that a music writer thinks of a piano. All of the inputs for a process are analogous to the piano keys and the composer (developer) uses the keys (inputs) of the piano (process) in the appropriate order to develop behaviors for the level (squad, battalion, etc) being addressed.

Benefits to army: The benefit of the results of this project will be a more flexible and rapid development of command and control simulations by taking advantage of the object-oriented model development paradigm. We think this effort will support the Object Management work. This effort will feed the development of behavioral object standards to be used by simulations such as JSIMS, WARSIM 2000, and OneSAF.

Work remaining to be completed: Statement of the goals, objectives, and accomplishments remaining for completion of the project.

- Confirm or deny the relevance of the All Behavior and Trichotomy hypothesizes.
- Finish development of the proposed Composable Behavior Model.
- Prototype the Composable Behavior Model by coding lowest to highest echelons.
- Test the model at all echelons.

Schedules with milestones: Accomplished and planned, including estimated completion dates.

- Gather and analyze the doctrinal materials that describe the Army's command and control processes to be represented. **Done**
- Gain familiarity with the Army's operational architecture (OA), CGSC instructional materials and with BPWIN, the software tool used to explore the OA. **Done**
- Examine the key OA diagrams showing the key commander and staff command and control functions at echelons from division to platoon and examined the processes at each level for similarities, differences and missing doctrinal materials. **90% complete. S-31 July**
- Develop reports and databases describing the inputs, outputs, required resources and so on associated with the C2 processes at each echelon. **90% complete. S-31 July**
- Identify doctrinal processes that are not important to the simulation world. **Done**
- Confirm or deny the relevance of the All Behavior and Trichotomy hypothesizes. **S-31July**
- Finish development of the proposed Composable Behavior Model. **S-31 August**
- Prototype and test the Composable Behavior Model by coding lowest to highest echelons. **S-30 September**

c. INTELLIGENT AGENT BASED OPFOR

Accomplishments:

- In coordination with CECOM and JPL, NSC has expanded the scope of the project. The CECOM matching funds have allowed us to include the objectives of porting the Smart Enemy Agent software to NT, linking it to our MACE environment, and integrating the JPL and MACE work with complementary CECOM software developments.
- JPL has developed a modeling framework for a Simulation Environment for Rapid Prototyping ENemy Tactics (SERPENT) based on:
    - computational electrostatics
    - embedded inline constructive simulation capability (currently CBS)
    - dataset representation
    - enemy template representations based on NSC SME input
- CECOM, JPL and NSC have established a coordinated information-exchange program of regularly scheduled teleconferences and face-to-face meetings to use the available resources more efficiently.

Lessons learned:

- Achieving credible realism with very few controllers in an easy-to-use and understand, fast-running division/corps simulation environment will require a state of the art user interface, advances in smart agent software technology, and simple--but believable—algorithms for the underlying movement, attrition and consumption processes.

Benefits to army:

- Development of a one-to-five person(s), user-friendly, graphically-oriented division/corps prototype wargaming environment useable for:
    - student training
    - autonomous assessment of human-generated Courses of Action (COAs)
    - testing algorithms and automated command decision software
- Reduction in the number of human-in-the-loop Opposing Force controllers at simulation driven exercises which will use future simulations such as JSIMS, WARSIM 2000, and OneSAF.
- Leveraging stable fusion algorithms developed by JPL, CECOM-sponsored research efforts, and NSC-developed simulation prototyping environment for maximum results at low cost.
- Successful completion of this project will provide the basis for a viable low-overhead driver component. A Low-overhead Driver will stimulate C4I devices and provide inexpensive staff training.

Work remaining to be completed:

- Port existing SERPENT agent software to NT platform
- Link JPL agent software with NSC-developed simulation prototype environment
- Agents will be provided for Latin America and Korea theaters with roles Movement, Attack, Artillery, and Engineer, using battalion, company, and platoon.
- Increase the fidelity of the underlying simulation based on established algorithms.
- Integrate agent software capability.

- Develop Human User/Software Agent cooperation capability.

Schedules with milestones for FY2000:

July 1998: Demo of Agent Software on Sun with CBS
Oct 1999: Port Existing Agent Software to NT Environment
Jan 2000: Installation and Integration of Oracle with Agent Software
Integration of Agent/Oracle with MACE
Armor Movement in Attack Formation in Korea Scenario

d. US ARMY TRAINING, EXERCISE, AND MILITARY OPERATIONS SIMULATIONS LABORATORY (TSL)

The Training, Exercise, and Military Operations Simulations Laboratory (TSL) develops simulation concepts, prototypes, and support tools for Army training, exercises, and military operations. Officially chartered by the Army's Training and Doctrine Command in December 1998, the TSL Lab develops prototypes that automatically replicate unit functions in computer simulations.

Inherent in this mission are the following tasks:

- Work to develop a robust synthetic environment for training through experimentation.
- Ensure that military doctrine is represented accurately in training simulations.
- Support integration of battle command capabilities and future information systems.
- Consider emerging technology in developing an improved simulation support base.
- Conduct experiments with and test innovative Command Decision Modeling (CDM) approaches.
- Support the Army Model and Simulation Office in the development of models and simulation standards and policies.

The TSL began developing prototypes in early 1998. In our first project we developed a cueing model to display the military decision making process based on the Army's business process model, the Operational Architecture. After successfully completing a prototype model, we began developing a computer simulation of ground combat forces to provide the environment for developing intelligent automated forces, one of TSL's primary missions. Current Army computer training simulations available to developers are old code, manpower intensive, and require high-end hardware or all of the above. We needed a faster than real time, flexible simulation which requires minimal support staff, and interfaces easily to other simulations, data bases and C4I devices. These requirements are driving our development of MACE.

e. MILITARY ART OF COMMAND ENVIRONMENT (MACE)

MACE and Simulation Based Acquisition

The Army's computer simulation training environments of today are large scale events requiring the portrayal of 2000+ units with the training audience widely dispersed at many locations. These exercises use 450-500 input devices and are often linked with as many as 50-60 command and control systems. These systems frustrate users because they are inflexible and unable to replicate all situations. A new approach that addresses user input and concerns throughout the early phases of acquisition must be developed. Tomorrow's process must facilitate increased interaction between user and developer.

The Simulation Based Acquisition (SBA) concept fostered by Dr. Pat Sanders, (Director, Defense Test, System Engineering and Evaluation), is based on user developer cooperation. He articulates the objectives of SBA as follows:

> "Reduce the time, resources, and risk associated with the acquisition process; Increase the quality, military utility, and supportability of systems developed and fielded; and enable integrated product and process development from requirements definition and initial concept development through testing, manufacturing, and fielding."

These are the goals we must all pursue in the acquisition of simulations. In major systems acquisition, simulation is used to articulate and share the vision of the end system. For a complex simulation acquisition, a simulation development environment should facilitate user involvement in all phases of software acquisition to explore and clarify requirements, experiment with technologies and understand human factor requirements.

The Army's frustrating experiences with the long acquisition lead times for combat simulations indicate that a new approach is necessary to field quality simulation tools. Therefore we began building a new prototyping, object-oriented environment. We have found that an object-oriented environment helps developers simplify complex functions into easily understood concise code. Our Military Art of Command Environment (MACE) is based on an object-oriented approach and a state-of-the-art case tool (Gensym's G2). We have developed our MACE simulation to the point where we now experimenting with command decision agents and are examining how the Army can develop future simulations to support planning, execution, and training.

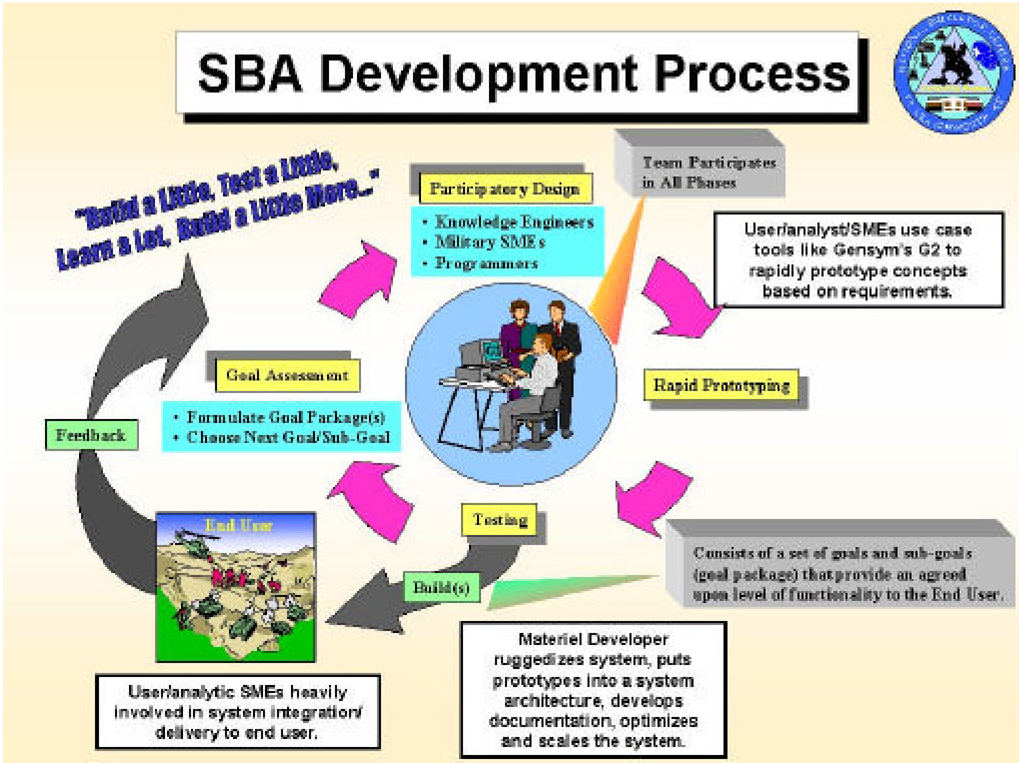


Figure 1 – TSL Prototyping Approach

In major systems acquisition, simulation is used to articulate and share the vision of the end system. For a complex simulation acquisition, our MACE simulation development environment facilitates user involvement in all phases of software acquisition to explore and clarify requirements, experiment with technologies and understand human factor requirements. Our approach to rapid prototyping is illustrated in figure 1. Prototypes can rapidly be developed to provide immediate feedback on the unknown interrelationships between requirements and system design so that spatial and temporal issues can be addressed early in development. This simulation based acquisition paradigm can greatly decrease life cycle development times and take advantage of leading edge technology.

If a simulation or other software-based product is breaking new ground, it may be very difficult to articulate hard requirements in the early phases of a program. Moving towards a very flexible software development process will provide a dramatic reduction in development and maintenance costs. To be effective, development processes must be able to incorporate late requirements changes identified by users. Such changes result from increased understanding of what is to be developed as well as from user adaptations to changes in missions and doctrine. Our MACE simulation effort has demonstrated that software environments exist which meet the development team's needs to respond to change.

The real benefit in this approach occurs in the early involvement of the user in the process. The key to SBA is the selection and use of comprehensive, flexible, and reasonably priced development software like G2 to decrease development time and costs while increasing product quality. Such software allows the user to immediately contribute to the development process because of its speed and flexibility.

MACE and Support to Battle Command Functions

MACE has shown its potential in many widely differing aspects of simulation employment far beyond SBA. The intent of the remainder of this paper is to focus on the wargaming aspects of MACE and demonstrate how it will be used to support course of action (COA) development and refinement within our experimental TOC capability.

Requirement for a Military Decision Making Process Support System

Currently, the Military Decision-Making Process (MDMP) is Planning-focused. Data is collected and processed periodically by the staff. To prevent information overload, this data is pre-processed prior to sending it to higher/ lower, echelons based on Commanders Critical Information Requirements (CCIR), reporting requirements, and time. The staff takes this data and attempts to transform it into a clear, concise picture of the current and future battlefield. This process builds inherent latency into the data. The process is labor intensive and time consuming. Often the commander and staff are limited in the detail and scope of their analysis by the time available to synthesize information and develop, compare and contrast alternative courses of action.

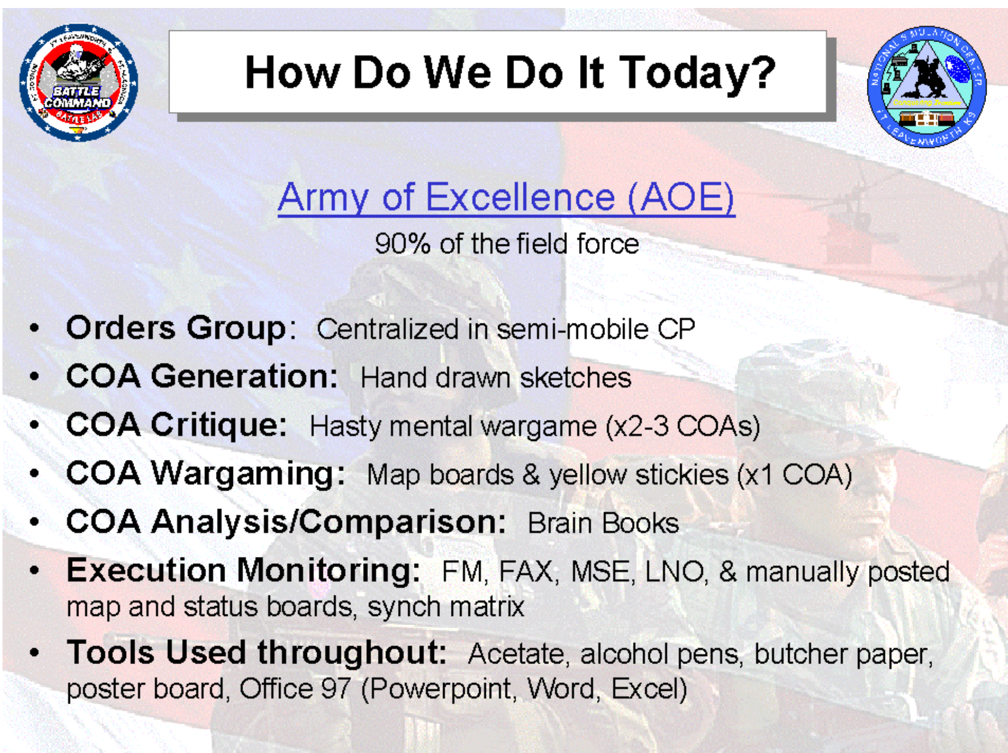


Figure 2 - Manual Process for COA Development

While the current MDMP results in some parallel planning, it is mostly sequential in nature. Each commander visualizes his or her own picture as a basis for decision. Once a Course of Action (COA) is decided, the commander's intent and the plan are sequentially passed to the next lower echelon for them to repeat the sequence.

Future battle command will require information technology that provides battlefield commanders with the ability to efficiently manage, synthesize and employ the enormous volumes of data and information available through advanced communications and sensor technologies. Simulation technology is a critical component of future command and control decision support systems. Increased operational tempo combined with the speed, flexibility and lethality of advanced technology equipped forces will demand commander-centric enhanced planning and execution monitoring capabilities. These capabilities also must provide integral support for rapid analysis and comparison of competing courses of action. Simulations will provide the commander a collaborative virtual environment for rehearsing and refining proposed plans. The result will be the ability to fight different or emerging conditions (enemy actions) and quickly adapt to a dynamic battlefield environment. Planning and decision support systems with integrated simulation technology will lead to increased situational awareness enabling a commander to initiate adaptive planning and execution.

MACE and Course of Action Wargaming

MACE has the speed and flexibility necessary to meet Army requirements as a combat unit course of action analysis and rehearsal tool. Army commanders need a stable, flexible and user friendly tool to rapidly develop combat courses of action and to rehearse them in a time constrained, highly stressful, widely distributed environment.

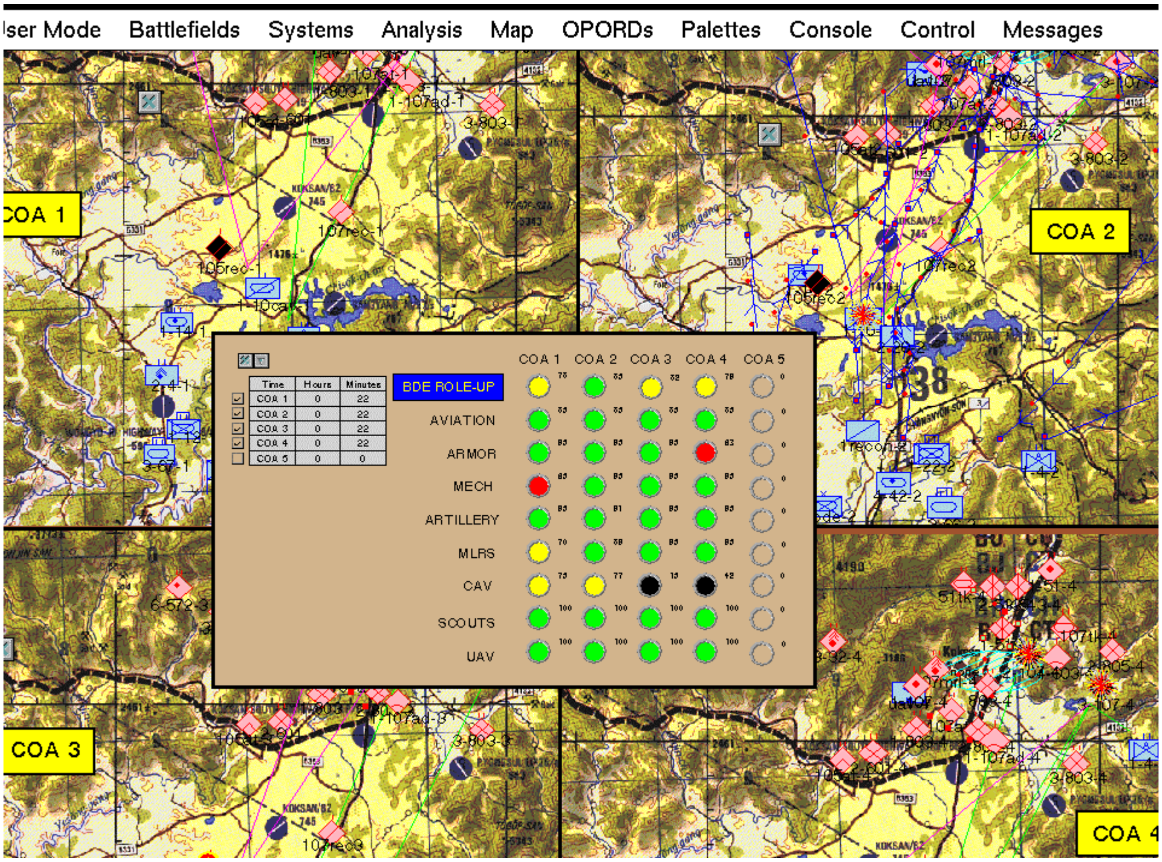


Figure 3 - MACE Running Four COAs Simultaneously

This type of simulation requires a simulation engine, accurate unit databases, terrain representation, units that can move, sense and conduct combat and an after action review system to provide easily interpreted combat results. It also needs to run at real time as well as twenty times real time and with the seamless ability to pause and resume. Our object-oriented development environment provides the capability to rapidly build our simulation with these capabilities and also the capability to easily generate scenarios, to add new functionality and to interface with tactical command and control systems. Our MACE Course of Action Analysis tool allowed our military analysts to develop Division and below courses of action with tactically accurate results on any battlefield and against any enemy in the world.

EVENT	CTRFIRE BATTLE/DEEP ATTACK	ATTACK	EXPLOITATION
UNIT			
DIV TRPS			
1-10CAV	1-10CAV blocks from PL Marie to PL Elsie H-hour to H+4 to prevent enemy direct fire on artillery units.	1-10CAV blocks from PL Marie to PL Elsie H+4 to H+10 to prevent enemy direct fire on artillery units and conducts passage of lines with 1-12MECH and 1-22MECH along PL Elsie.	D/1-10CAV screens forward of and along the flanks of 3-67AR's exploitation H+10 to H+20.
2-20FA	2-20FA suppresses enemy air defense H+0 to H+2 and neutralizes enemy artillery and mortars H+2 to H+4.	2-20FA reinforces 4-42FA in zone H+4 to H+10.	2-20FA reinforces 4-42FA in zone H+10 to H+20.
2-4FA	2-4FA neutralizes enemy artillery and mortars H+0 to H+4	2-4FA neutralizes enemy artillery and mortars H+4 to H+10	2-4FA neutralizes enemy artillery and mortars H+10 to H+20.
1-14FA	1-14FA suppresses enemy reconnaissance and infantry units in direct support of 1-10CAV H+0 to H+4.	1-14FA reinforces 4-42FA in zone H+4 to H+10.	1-14FA reinforces 4-42FA in zone H+10 to H+20.
1-4AV	1-4AV attacks enemy armor and artillery in engagement area CAT H+2 to H+4.	1-4AV refuels and rearms at base H+4 to H+10	On Order, 1-4AV attacks enemy forces along the flanks of 3-67AR H+10 to H+20.
1BDE HQ	1BDE HQ occupies assembly area DOG H+0 to H+4 preparing for attack.	1BDE HQ moves behind 1-22MECH to OBJ MOUSE H+4 to H+10.	1BDE HQ moves behind 3-67AR H+4 to H+10.
1BDERCN	1BDERCN occupies assembly area DOG H+0 to H+2 preparing for attack. 1BDERCN conducts reconnaissance across the 1BDE zone H+2 to H+4 to confirm enemy locations.	1BDERCN conducts passage of lines with 1-10CAV along PL Elsie and conducts reconnaissance across the 1BDE zone H+4 to H+10 to confirm enemy locations.	1BDERCN conducts reconnaissance along the WONSON Highway ahead of 3-67AR H+10 to H+20 to confirm enemy locations.
1-12MECH	1-12 MECH occupies assembly area DOG H+0 to H+4 preparing for attack.	1-12 MECH conducts passage of lines with 1-10CAV along PL Elsie and attacks in zone to seize OBJ RAT NLT H+10 to allow 3-66AR and 3-67 AR to exploit north along the Wonson Hwy.	1-12MECH controls OBJ RAT H+10 to H+20 supporting 3-67AR's exploitation.
1-22MECH	1-22 MECH occupies assembly area DOG H+0 to H+4 preparing for attack.	1-22 MECH conducts passage of lines with 1-10CAV along PL Elsie and attacks in zone to seize OBJ MOUSE NLT H+10 to allow 3-66AR and 3-67AR to exploit north along the Wonson Hwy.	1-22MECH controls OBJ MOUSE H+10 to H+20 supporting 3-67AR's exploitation.
3-66AR	3-66AR occupies assembly area DOG H+0 to H+4 preparing for attack.	3-66AR follows and supports 1-22MECH in zone H+4 to H+10 to assume 1-22MECH mission if necessary.	3-66AR becomes the BDE reserve vicinity PL
3-67AR	3-67AR occupies assembly area DOG H+0 to H+4 preparing for attack.	3-67AR is the Brigade reserve. 3-67AR follows 1-12 MECH to Check Point 7 and waits.	3-67AR exploits north along the Wonson Hwy H+10 to H+20.
4-42FA	4-42FA occupies assembly area DOG H+0 to H+4 preparing for attack.	4-42FA provides direct support to 1 BDE H+4 to H+10. Priority of fire to 1-22 MECH, 1-2MECH in order.	4-42FA provides direct support to 1 BDE H+10 to H+20. Priority of fire to 3-67AR, 3-66AR in order.

Figure 4 - Prototype Sync Matrix for MACE Command Agents

We are teaming with the Battle Command Battle Laboratory to develop a course of action development system integrating several lead-edge technologies. A novel prototype battle command decision support system will be developed through the integration of several on-going technology efforts to support future battle command initiatives. Integration of these technology efforts will provide an initial end-to-end automated capability for generating and analyzing multiple courses of action in detail, in less time, and with reduced level of effort. The Semi-Autonomous Planning, Preparation, and Execution Review (SAPPER) program offers a potentially revolutionary capability for conducting commander and battle staff training by facilitating rapid generation of planning products and by providing real time feedback and recommendations on feasibility, acceptability, and suitability. The proposed system will enable the user to rapidly change initial conditions to generate an action/reaction response cycle with which to develop and evaluate commander and staff proficiency.

Our plan involves combining the capabilities of three cutting edge projects. HPKB is DARPA's High Performance Knowledge Bases COA critiquing prototype. It analyzes proposed courses of action, provides assessments of their viability, strengths and weaknesses, and suggests improvements. CADET is a battle-planning tool under development by CECOM which helps planners translate an initial maneuver COA into a detailed COA. The third tool is MACE and its simulation capabilities.

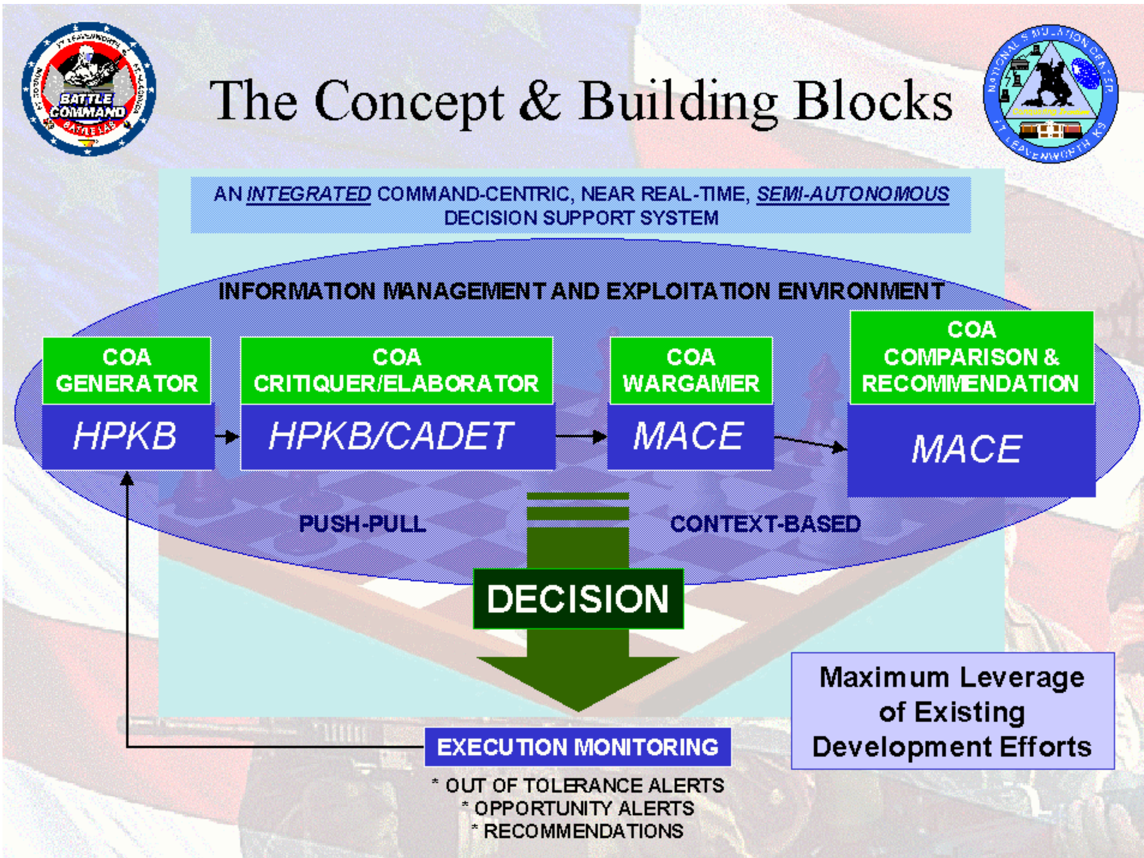


Figure 5 - SAPPER Integration Concept

The significant near and long-term benefits to the Army are the enhanced ability of the commander to quickly develop, game, choose, and rehearse COAs. Course of Action development, analysis, and selection are the most critical and often the most time-consuming aspects of the Military Decision-Making Process. Coordinating and rehearsing the results of the process with subordinate and higher headquarters are often slighted for lack of time or distance considerations. SAPPER will address all of these shortcomings. The system has the potential to greatly decrease the time the commander and staff must spend on developing, analyzing and selecting high-quality courses of action, and it's MACE component will support long-distance, real-time coordination and rehearsal of COAs. SAPPER also will provide unique training capabilities to commanders and staffs by allowing them to practice decision-making skills using systems present in their command posts and to receive immediate feedback. Finally, the SAPPER components will demonstrate the effectiveness of AMSO

standards by implementing Composable Behaviors, Battle Management Language (BML), and Command Agents in MACE and by examining the possibility of incorporating standards from other categories such as Terrain, Object Management, Environment, and Move.

Future

Continuing efforts include supporting a major 6th Fleet Exercise for the Navy War College involving an upgrade to the work we have already done with the Navy Space and Naval Warfare Systems Command.

We are working with the Army Combined Arms Support Command to begin federating use their SIMULOGS program through HLA as a logistics driver for MACE.

Our efforts with the Command and General Staff College in supporting classroom instruction will continue with a possible expansion into working with the Army's recently announced "Strike Force" concept.

Internally we intend to make MACE HLA compliant and to continue our work to link MACE with all of the new command and control systems the Army is developing. This is pioneering work to link these systems with interactive simulations and requires G2's robust bridging capability. Major functionality added is a 3D-terrain generation capability employing VRML/Web interface and JAVA. Additionally we are spending a great deal of time adding doctrinally correct object-oriented military map graphics to support rapid revisions in courses of action and visual clarity and appeal.

Summary

The TSL will continue to develop MACE and its derivatives in support of Army simulation concepts, prototypes, and support tools for training, exercises, and military operations. Gensym's G2 has been key to our success in rapidly developing a simulation environment and prototyping course of action analysis tools for the Army and Navy. G2 strongly complements our use of the simulation based acquisition paradigm and the combination of the two greatly decreases life cycle development times.

PRIORITIES FOR NEXT YEAR

1. **Development of normative CDM Standards for the M&S Community. Below is the timetable.**

Standards and Timetable for Implementation into SNAP	
STANDARD	DATE
Battle Management Language I (Signed May 99)	APPROVED
CDM Technology Assessment	20 Aug 99
Sleep Management System	3 Sep 99
Cmd Agent Architecture	24 Sep 99
Composable Behavior	15 Oct 99
Battle Management Language II (Future AMIP Effort)	TBD

2. **Conducting research on and prototyping of command agent architectures, normative behavior models, and object-oriented behavioral representation. Below is our AMIP proposal.**

Battle Management Language Level 2 (Echelons, BOS, Commander's Intent, Graphics)

Executive Summary

Battle Management Language Level 2 (BML 2) will be a continuation of the success of the original BML. It will expand the breadth of the language, increase its terms and add "intelligent" graphics and Commander's Intent Language (CIL). A battle management language or BML is the military verbiage or vocabulary that military planners and operators use to provide a paper or digital order to a simulation and receive back reports in a language that the men and the machine understands. The language must work man to man, man to machine, and machine to man. Simulations which execute Command Decision Modeling (CDM) use a BML to allow "Intelligent Agents or "Handlers" to interface with the human controller in the doctrinal language which will be familiar to him or her.

In BML1 we established FM 101-5-1/MCRP 5-2A Operational Terms and Graphics as the primary source for man/simulation communication terms. Our emphasis was combat forces at all tactical levels with less attention to combat support and combat service support units. In BML-2 we will continue to emphasize joint doctrinal sources. Also we will improve the richness of the BML by identifying terms that apply to specific echelons (soldier– Corps) and to one of the seven battlefield operating systems.

The most important improvements in BML-2 will be the addition of military graphics symbols based in doctrinal sources that can be reasoned upon in object oriented programs and the initial efforts to communicate commander's intent. The military graphics symbols are a part of the Battle Management Language which represent military actions to the machines and the man and the CIL will represent the "why" of the military actions

Background and Technical Description of the Problem

Representing command and control decision-making in software is one of the critical and challenging tasks confronting the simulation community. With the development of simulations such as WARSIM 2000, JSIMS and JWARS, the Modeling and Simulations Community is shifting toward support of larger-scale, higher-fidelity exercises. These larger simulations drive an increased requirement for 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. Until the approval of BML this spring, the controllers and role players had to learn a new language in order to send orders and information to the simulation and to interpret the reports that the simulation returned to them. With BML, this man to machine, machine to man communications is accomplished in the doctrinal language familiar to all people with a military background eliminating the need to learn new languages for each simulation.

BML 1 is the foundation of this approach to standard simulation input/output, but it is not complete. BML 2 will begin the process of enriching the language by addressing terms that apply to a specific echelon or limited number of echelons. Similarly it will address terms that may be unique to one or more Battlefield Operating Systems (BOS). BML 2 will continue coordination with the Joint Common Database that is used by the C4I devices to which modern simulations must link and will explore the possibility and potential payoff of developing a BML based on foreign doctrines.

BML 2 will address two other areas that are very important to Command Decision Modeling. Military graphics provide commanders, especially at brigade level and lower, with a key tool to use in communicating orders to subordinates and to provide commanders with a rich source of information regarding their current missions. BML 2 will provide a doctrinal basis and a proven approach to representing graphics in simulations. It will also begin to address the complex task of expressing commander's intent, the "why" of the "who, what, when, where, and why" of a standard mission statement.

Technical Approach

As with BML 1, this project requires research into military doctrinal publications available to us on the internet. We will establish the echelon and battlefield operating system framework and coordinate it with our doctrinal experts. Once we have consensus on the framework, we will do a term by term analysis of FM 101-5-1 and other pertinent doctrinal sources and array the terms in the framework. After coordination on the reflector and a number of other agencies this portion will be complete. The graphics package will require an analysis of FM 101-5-1 to determine which graphics require depiction and the most efficient, object-oriented method to depict the selected graphics. We will develop a prototype of a graphical system on which intelligent agents can reason and demonstrate its capabilities in our developmental system, J-MACE. Commander's Intent Language also will require doctrinal research and coordination with Subject Matter Experts. We will then develop a syntax for encoding commander's intent and a dictionary of important terms. Time and resources permitting, we will investigate development of an OPFOR BML using current Army doctrinal publications and Combat Training Center's OPFOR publications.

Products

- reference dictionaries in the form of annexes to BML 1 to cover BML by echelon and by BOS.
- a prototype simulation employing object-oriented graphics with documentation and users guides.
- a syntax and a dictionary of terms for a Commander's Intent Language published as an annex to BML 1.
- a paper addressing the value of developing a BML for a foreign doctrine, and if appropriate a sample foreign BML annex.

Milestones

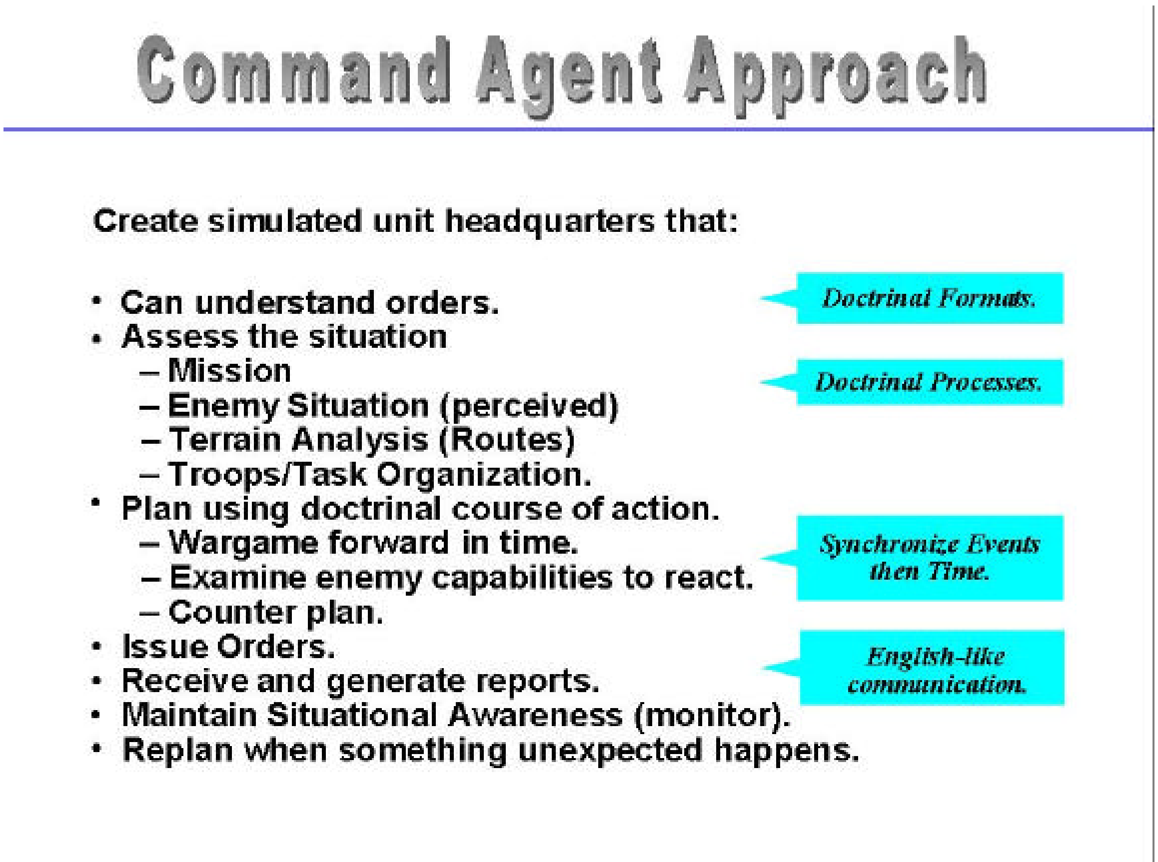
Milestone	1	2	3	4	5	6	7	8	9	10	11	12
Establish and coordinate Echelon, BOS and Commander's Intent frameworks	X	X	X	X								
Term Analysis and Coordination			X	X	X	X						
Graphics Analysis						X	X	X				
Graphics Coding and Coordination								X	X	X	X	
Coordination and voting BML 2											X	X
Foreign Doctrine BML possibilities	X	X	X	X								
Develop and Coordinate Foreign Doctrine BML				X	X	X	X	X	X	X	X	
Coordination and voting Foreign Doctrine BML											X	X

Risk/Benefit Analysis

BML 2 with Graphics provides further standardization of military doctrinal language into simulation and C4I products which allows man to man, man to machine and machine to man interfaces in the same language. This allows command decision modelers to create automated forces which can react to human higher headquarters with credibility. Automated forces allow reduction of training overhead for future simulations such as WARSIM 2000. BML 2 also supports Joint Common Data Base (JCDB) improvement to support simulation links to current and proposed C4I systems which improves training realism and operational efficiency.

3. Develop a collective requirements document for CDM to identify product expectations.

At the May Workshop, the group spent some time developing a set of requirements with an associated timeline to frame this effort. The below slides capture the CDM groups views.



The group determined that it was important to follow a doctrinal approach for command agent development so we categorized our initial look at requirements into a format that

Taking the steps of the command agent approach as the end states, we formulated the ways and means we thought were necessary to achieve automation/automated assistance of the

We then assessed the means as near-term, mid-term, and far-term to provide some sense of when we thought the CDM community would have sufficient usable standards to support automated implementation of the end states.

FY 01-07 Requirements

ENDS	WAYS	MEANS
Understand Orders	Commander's Intent Natural Language Processing	(N) Battle Management Language (F) Commander's Intent Language
Assess Situation (METT-T)	Terrain Reasoning Perceived Truth Monitor Current Situation	(F) Information Latency (M) Agt Based Graphical Reasoning (N) Cdr & Staff Composable Behaviors
Develop Plan	Generate/Evaluate/Select COA Synchronize Tasks Graphical Reasoning Resource Allocation Forecast	(M) Agt Based Graphical Reasoning (N) Cdr & Staff Composable Behaviors (F) COAA Generation Tools
Issue Orders	Natural Language Processing Information Flow	(N) Battle Management Language (F) Commander's Intent Language (M) Agt Based Graphical Reasoning (F) Information Exchange With C4I
Receive and Generate Reports	Natural Language Processing	(N) Battle Management Language (M)Agt Based Graphical Reasoning (F) Information Exchange With C4I

FY 01-07 Requirements

ENDS	WAYS	MEANS
Maintain Situational Awareness	Perceived Truth Identify Situational Interrupts	(F) Information Latency (F) Develop Commanders Perception (F) Information Exchange With C4I
Replan	Adjust to Situational Interrupts Repair or Replan	(F) Develop Commanders Perception (F) Plan Repair

Near Term 01-02

Mid Term 03-04

Far Term 05-07

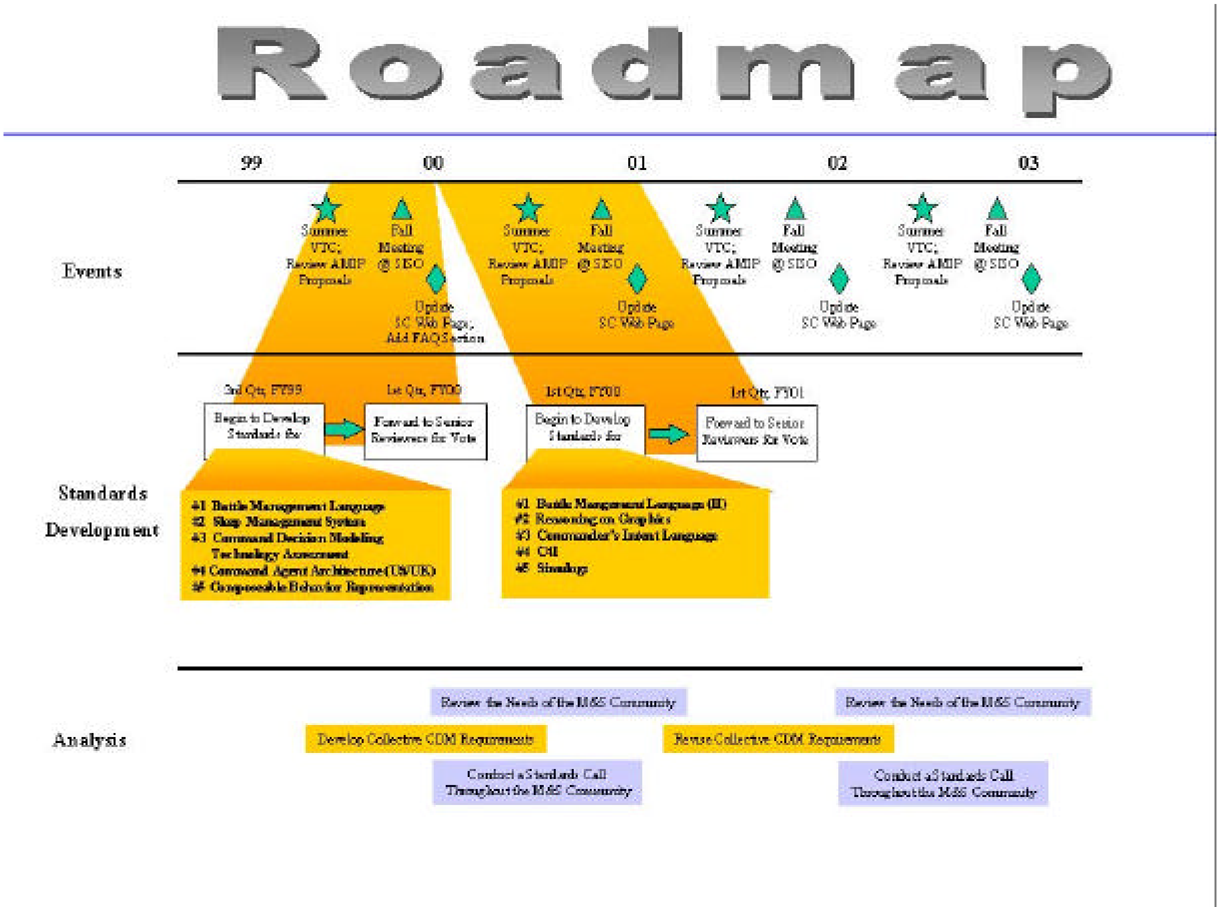
1.

decision modeling technology. Below is a table of members of the CDM team that are working various projects in this area.

Name	Organization	Position
Sean MacKinnon	NSC	Chair
Marilyn Macklin	DCSINT	Co-Chair
Lashon Booker	MITRE	Member
Dick Brown	TPIO-ABCS	Member
Kay Burnett	NGIC	Member
Dr. Chris Elsaesser	MITRE	Member
Kevin Gipson	NSC	Member
Jenni Henderson	UK DERA	Member
Clark Karr	SAIC	Member
Bob Leath	CECOM	Member
Dave Loental	TRAC	Member
Janet Marrow	NGIC	Member
MAJ John McKitrick	SACC	Member
Dirk Ourston	SAIC	Member
Barbara Pemberton	STRICOM	Member
Sean Price	UK RMCS	Member
Joe Provenzano	JPL	Member
MAJ Gene Stockel	BCBL	Member
Kelley Stephens	TPIO-ABCS	Member

This list is not all-inclusive and membership is open to all government agencies, academia, and industry as well as international participation. The CDM SCC typically distributes reports and other information to 100 plus members. This truncated list represents those that have been most active in supporting the standards category.

ROADMAP



Roadmap
99
00
01
02
03
Events
Summer VTC; Review AMIP Proposals
Fall Meeting @ SISO
Update SC Web Page; Add FAQ Section
Update SC Web Page
Standards Development
3rd Qtr, FY99
1st Qtr, FY00
1st Qtr, FY00
1st Qtr, FY01
Begin to Develop Standards for
Forward to Senior Reviewers for Vote
#1 Battle Management Language
#2 Ship Management System
#3 Command Decision Modeling Technology Assessment
#4 Command Agent Architecture (US/UK)
#5 Composeable Behavior Representation
#1 Battle Management Language (II)
#2 Reasoning on Graphics
#3 Commander's Intent Language
#4 C4I
#5 Simulogy
Analysis
Review the Needs of the M&S Community
Develop Collective CDM Requirements
Revise Collective CDM Requirements
Conduct a Standards Call Throughout the M&S Community

Annual Standards Category Report for FY00

COMMUNICATION SYSTEMS

STANDARDS CATEGORY DEFINITION

The Communication Systems category standards include the objects, algorithms, data, and processes necessary to replicate friendly and enemy Control, Computer, and Communications (C3) systems and processes

STANDARDIZATION REQUIREMENTS

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

1. Define and design objective C3 systems M&S representations.
2. Coordinate common C3 systems representations with other categories.
3. Upgrade current M&S capabilities to replicate existing and emerging C3 systems.
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 to allow communications effects to play in combat models.
7. Develop MOE'S to identify key elements and validation tolerances for CS M&S.
8. Insure the models are available to users.

ACCOMPLISHMENTS AND ASSESSMENT

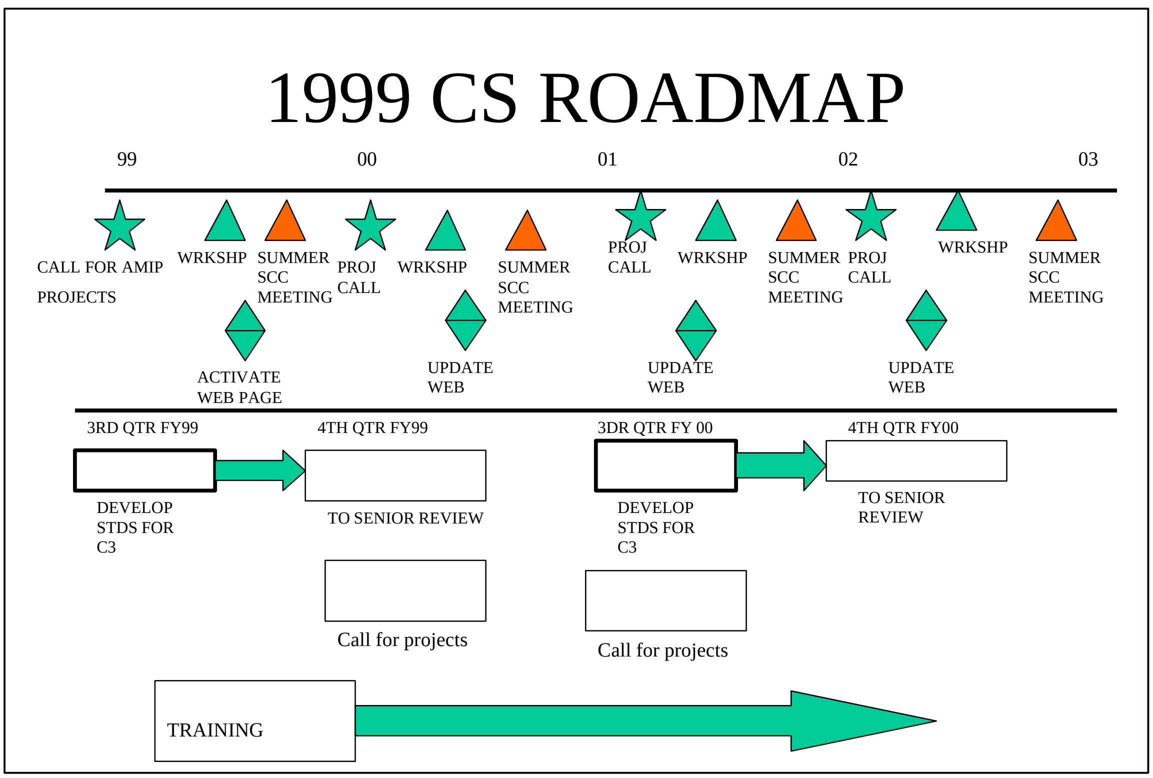
The Communications Systems WEB page has been updated once this year and will be reviewed in September to determine if further update is needed.

The CS submission to the ASTARS program has been approved for inclusion as an approved standard. The standard indicates that the commercial modeling tool of OPNET is the tool of choice for communications systems modeling. Having a preferred tool will aid in attaining interchangeability and commonality of elements. A constant review of the tools available on the market will be conducted to insure that new development tools are evaluated and can also be deemed a viable standard.

PRIORITIES FOR NEXT YEAR

1. Submit draft standards to the ASTARS program.
2. Maintain and improve team membership.
3. Keep WEB page current.
4. Define the procedures of operation for a repository for communications models developed using OPNET as the tool.
5. Establish statistics packages that can represent traffic to be used as loading for models. Provide documentation on the use/methodology appropriate to utilization of the statistics.
6. Specify a force structure, geography, and architecture to be used for communications modeling. Use of a common military makeup will allow comparison between different models.
7. Provide education.

ROADMAP



Annual Standards Category Report for FY00

COST REPRESENTATION

STANDARDS CATEGORY DEFINITION

The Cost Representation standards category addresses Army standard cost definitions and the data, tools, algorithms and techniques necessary to accurately and consistently prepare and portray cost and economic analyses for military operations, acquisitions, and modeling and simulation activities.

STANDARDS REQUIREMENTS

Develop, document, and promote Army standard cost definitions, data, tools, algorithms and techniques for preparing and portraying cost and economic analyses for military operations, acquisitions, and modeling and simulation activities. Standardize techniques for comparing the costs of alternatives. As necessary, update the Army's principal publications containing cost standards and guidance: AR11-18, *The Cost and Economic Analysis Program*; the *Department of the Army Cost Analysis Manual*; and the *Department of Army Economic Analysis Manual*. Lead Army Cost Analysis initiatives in support of Simulation Based Acquisition (SBA). Interface with the other Army Model and Simulation Standards Categories.

ACCOMPLISHMENTS AND ASSESSMENT

The U.S. Army Cost and Economic Analysis Center (CEAC) chairs the Cost Representation Standards Category. During the last year, CEAC continued to develop, improve and field cost estimating tools and models, and cost databases. The major accomplishments follow:
Updated the Automated Cost Estimating Integrated Tools (ACEIT) resulting in reduced calculation time, enhanced import/export capabilities, improved linkage to the materiel commodity-based Automated Cost Data Base (ACDB), and an improved RI$K Executive. ACEIT is the standard Army automated framework/spreadsheet that is designed to improve reporting consistency and increase productivity of cost analysis work. The Army, Air Force and the Navy endorse ACEIT as the recommended tool for their cost analysts to use. ACEIT automates the detailed, tedious costing functions and documentation allowing analysts more time to develop costing methodology and perform analysis. The ACEIT model is improved continuously. ACEIT includes a Cost Analysis Statistical Package (CO$TAT) that supports the requirement of cost analysts to assess risk in cost estimates. 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.

Updated and expanded the Automated Cost Data Base (ACDB), containing cost, technical and programmatic data from Contractor Cost Data Reports (CCDRs), Contractor

Performance Reports (CPRs), contracts and other sources. The Army databases currently hosted in ACDB include: communications and electronics, rotary wing aircraft, tri-service missiles and munitions and wheel and track vehicles. The Air Force and Navy also have databases hosted in ACDB.

Updated the Force and Organizational Cost Estimating System (FORCES) model, 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 for cost factors and increased capabilities. A Contingency Operations Model will be added to this suite and a TDA Costing Model is planned for the future.

Updated and expanded the Operating and Support Management Information System (OSMIS), an automated database of normalized, actual materiel operating costs used for Army OPTEMPO budgeting and Operations and Support acquisition costing. This data is collected annually, analyzed, distributed and used Army-wide.

CEAC continued to promote Army cost and economic analysis standards by distributing the Department of the Army Cost Analysis Manual and the Department of the Army Economic Analysis Manual, by facilitating the training of Army cost analysts in the use of ACEIT, and by providing expert cost estimating guidance. Five additional items, (the Force and Organizational Cost Estimating System (FORCES), the Army Military-Civilian Cost System (AMCOS), the Automated Cost Estimating Integrated Tools (ACEIT), the Automated Cost Database (ACDB) and the Operating and Support Management Information System (OSMIS) have been added as standards.

PRIORITIES FOR NEXT YEAR

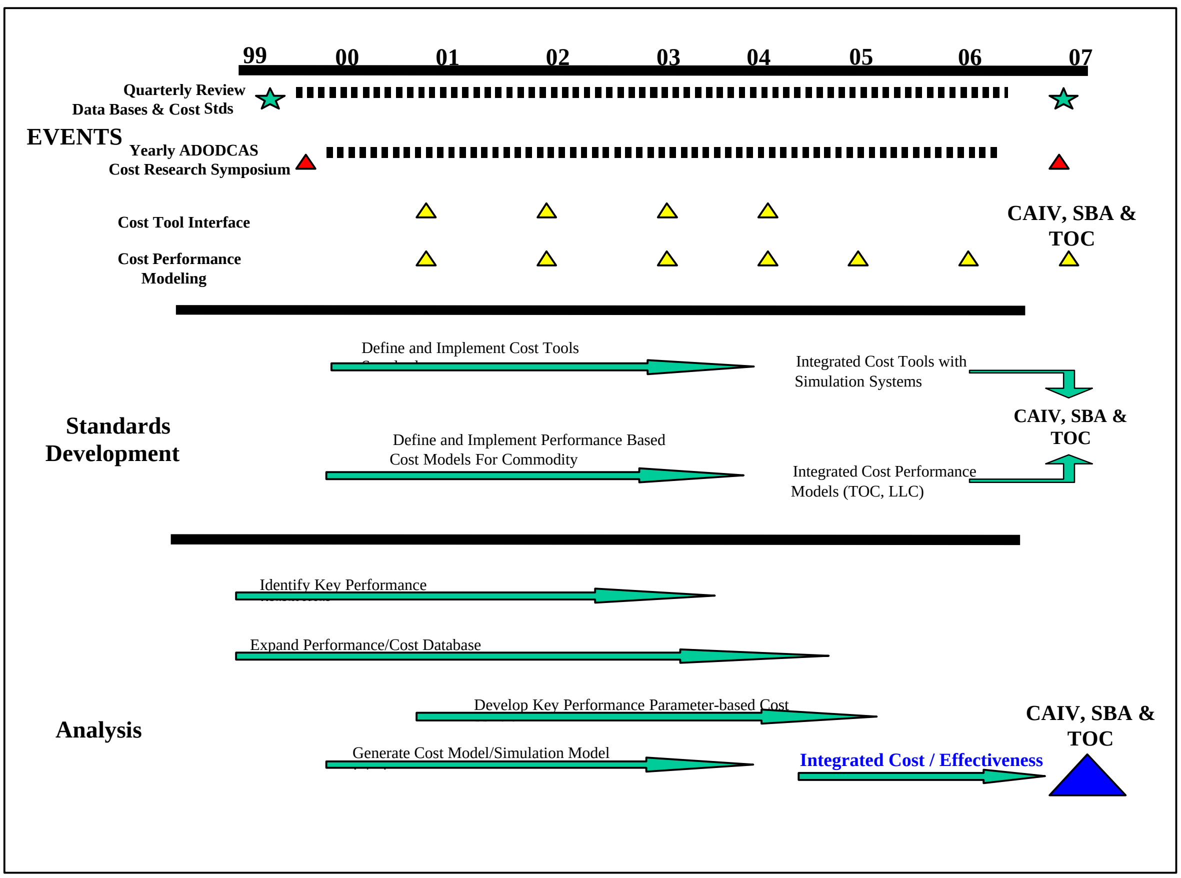
1. Maintain latest information on the CEAC web site http://www.ceac.army.mil/default.htm
2. Continue to integrate and improve the various cost models and databases (ACEIT, CCDR, OSMIS, FORCES, and AMCOS).
3. Review the Department of the Army Cost Analysis Manual and the Department of the Army Economic Analysis Manual to determine if an update is needed to reflect the dynamic environment initiated by Acquisition Reform, the National Performance Review, and other initiatives.
4. Provide validation and verification of cost in models and simulations, as required.

5. Provide support to improve and expand applications, cost methods, and databases.
6. Develop new databases, tools, algorithms and techniques necessary to accommodate Simulation Based Acquisition (SBA) initiatives.
7. Nominate and obtain approval of additional Cost Representation standards via the *Standards Nomination and Approval Process* (SNAP) and the *Army Standards Repository System* (ASTARS).
8. Expand the interfacing and coordination of the Cost Representation Standards Category with the other models and simulation Standards Categories.

ROADMAP

The following figure highlights the goals, events and processes of the Cost Representation Standards Category during the entry into the 21st Century:

COST REPRESENTATION SUMMARY ROADMAP



The objective of the roadmap is a model that will provide cost based on performance as well as battlefield effectiveness. This includes two concurrent efforts articulated in FY00 AMIP proposals that require development over the Program Objective Memorandum (POM) years. One effort develops the interface tools for cost models to communicate with the other standards categories. The other effort generates the integrated cost and effectiveness model. The developmental efforts will culminate in a model that robustly addresses Simulation Based Acquisition, Cost as an Independent Variable, and Total Ownership Cost.

Annual Standards Category Report for FY00

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 standards for nomenclatures, data element representation (data models), data interchange formats, data verification, validation, and certification, data modeling standards, and other software related to databases and data visualization. The category works with the other standards categories to assist them in identifying and applying data standards.

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 entities. Without these standards, users of data cannot be certain that they are correctly representing the entities in models and simulations. Priority should be given to the identification, proliferation and incorporation of standards into new and existing databases. For this to occur, priority must also be given to developing standard data models and incorporating them into the DoD Data Dictionary.

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 data interchange formats for information exchange.

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 so that standards development and data interchange can occur in the most efficient manner.

4. Develop Standard Data Models. To develop and maintain data standards for M&S data, it is important to develop standard data models that serve as subject area information models. These subject area information models define terms and formats that can be

used as a basis for new database construction and automated data interchange software development.

5. Expand Education. Education includes training, workshops 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 meets quarterly to assess requirements and review work. In FY 99, a core group of principle players (AMSO, ARL, AMSAA, NGIC, TRAC, and CAA) formed the DATA Process Action Team to investigate issues associated with the use of characteristics and performance data in combat simulations. The group typically worked projects of community interest such as the Characteristics and Performance Data Interchange Format (C&P DIF) and Standard Nomenclature projects.

AMIP co-sponsored an FY99 task with the group to continue development (C&P DIF). The overall goals of this task are to develop a standard C&P subject area of interest model and mappings from AMSAA and NGIC to this model. In doing so, standardized data elements are to be identified and submitted to the DoD Data Dictionary. This project supports Army data standards initiatives by providing common representations for C&P data in Army combat areas. The C&P subject area of interest model (to be completed around July 99) can be used as a springboard for mapping other databases to the standard. Construction of interchange software is anticipated to begin in 4Q99. Initial efforts will provide AMSAA performance data in the formats specified by the DIF.

The working group continued work on the refinement of Standard Nomenclature Database in FY99. This project leverages the current Standard Nomenclature Database at TRAC-FLVN into a web-based system. Key players in the effort are TRAC, NGIC and AMSAA. These agencies are developing standard naming conventions for platforms (M1A1, M2A2, etc.), munitions (M829A1, TOW, etc.), and weapons (M16, AK-47, etc.) and designing user access tools that comprise the new system. The initial version of the new system will be accessible on SIPRNET in the 4Q FY99 time frame. The system will include the Modern Integrated Database Code (MIDB Code) so that it can be linked to the MIDB and other systems which utilize it. This will allow users to tie together performance data and intelligence data.

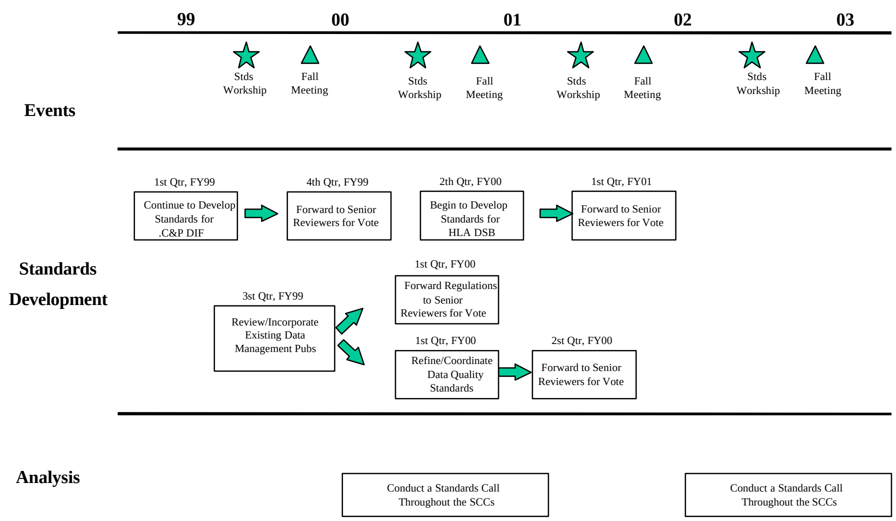
PRIORITIES FOR NEXT YEAR

The focus of the Data Standards Category for FY00 will be on the continued development and implementation of data standards and the data infrastructure. The focus to date has primarily been oriented towards combat. Successful completion of the standard data interchange format and the standard nomenclature system efforts will put the Army on solid footing in that area. Given those expectations, FY00 represents a transition year in that the focus will begin to shift from combat simulation to a more general look at all simulation areas. The Data Standards Category will partner with the other standards categories for establishing priorities and conducting projects. This effort has begun with the proposal of cross category projects (FDB on High Level Architecture Dynamic Scenario Builder and C4I on Joint Common Database).

ROAD MAP

The vision of the data standards category is to continue identification and development of standards that increase the Army's efficiency in conducting analyses through modeling and simulation. The figure below presents a road map for attaining that vision.

DATA ROADMAP



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DEPLOYMENT AND REDEPLOYMENT

STANDARDS CATEGORY DEFINITION

Deployment and redeployment standards address objects, processes, procedures, techniques, algorithms, data, 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 CONUS bases or areas of operations.

The focus of the standards category is the Defense Transportation System (DTS).

The functional definitions for deployment/redeployment are as follows:

Deployment: The relocation of forces and materiel to desired areas of operations. Deployment encompasses all activities from origin or home station through final destination, specifically including intertheater and intratheater movement legs, staging, and holding areas.

Redeployment: The transfer of a unit, an individual, or supplies deployed in one area to another location within the area, or to the zone of interior for the purpose of further employment.

As a sidenote, 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.

STANDARDIZATION 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 standards for the representation of all aspects of the DTS and deployment/transportation, including forces (equipment, personnel, and supplies), transportation assets, cargo, and infrastructure.
- Develop and document deployment related publications, algorithms, heuristics, processes, etc. at various levels of resolution.
- Ensure commonality and linkages with mobilization, logistics, and warfighting models and simulations.

ASSESSMENT

The Department of Defense, CINCs, and Services are moving forward to improving the deployment process and standardizing deployment models and simulations. One such initiative is the Transportation Analysis, Models and Simulations (TAMS) functional process improvement. TAMS is a USTRANSOM Joint Transportation Corporate Information Management Center (JTCC) initiative to assess M&S capabilities currently employed within the DTS. The JTCC has an OSD charter to make recommendations on migration systems. The USTRANSCOM Plans and Policy Directorate TC-J5 sponsored the project. The primary purpose was to recommend a selection of systems to provide an end to end modeling and simulation capability to support the operational components within USTRANSCOM's Global Transportation Network (GTN). The secondary objective of TAMS was to determine functional requirements for the transportation portion of the Joint Simulation System (JSIMS) and Joint Warfare System (JWARS). The TAMS project was initiated to reduce costs of unnecessary redundant functions through systems migration, providing a common set of tools for planning and execution, provide a single transportation answer to queries from all levels, and provide an integrated fort-to-foxhole capability for the areas of Transportation Feasibility Analysis, Programmatic Analysis, and Wargaming. In 1996, USTRANSCOM/JTCC held several workshops to define the current "As-Is" capabilities of deployability M&S. It also held several "To Be" workshops to determine requirements for Transportation Feasibility, Programmatic Analysis, and Wargaming. Participants in the TAMS workshops included USTRANSCOM, the warfighting CINCs, the Joint Staff, OSD, and the Services.

As a result of the TAMS process, JTCC recommended nine Migration Systems currently in use and under development in DoD. These included a desktop system, a shell system, and several other tools that model and simulate various aspects of the Defense Transportation System. These recommended systems have been staffed to the CINCs and Services. After final concurrence, the TAMS recommended Migration Systems will be forwarded to OSD for final approval.

It is not the intent of the Deployment Standards Category to focus primarily on the TAMS Migration Systems or exclude requirements of legacy systems not recommended by TAMS. However, the TAMS systems will provide a good foundation for the development of requirements (and standards) for end-to-end deployment M&S. We will continue to team and invest as necessary to further develop these and other standards and ensure deployment M&S comply with Army and DoD standards such as the HLA.

ACCOMPLISHMENTS

The standards category received AMIP funding in FY 98 and initiated development of an extensible object hierarchy for deployment models and simulations. The standards category also received additional funding in FY 99 for continuation of this project. This project is evaluating and standardizing the class hierarchies and attribute data of existing detailed models and simulations, and will extend the hierarchies to other deployment models and simulations. This bottoms-up approach will initially focus on detailed objects and attributes of seaport and installation tools, be applied upward to less detailed tools, and then be used to develop a minimal set of abstract deployment objects. The first phase of this project, the transportation class hierarchy, is almost complete. The standards category will forward this hierarchy for standards approval prior to the end of FY 99. FY 99 funding received in December 1998 is being used to expand the hierarchy to include infrastructure and resource classes.

The standards category also received funding in FY 99 to support the development of an Infrastructure Data Structure standard. This project is defining a common data structure that will support the transfer of Geographical Information System (GIS) data to deployment/transportation M&S. We expect this project to be completed in the first quarter of FY 00.

The standards category received approval for two standards in FY 99. They are as follows:

1. Logistics handbook for Strategic Mobility Planning (MTMCTEA Reference 700-2). This reference provides a broad range of vital transportation information and guidance for planning purposes. It contains general planning considerations and guidelines for each transport mode (motor, rail, sea, and air), containerization data, cargo density information, etc.

2. TB 55-46-1 STANDARD CHARACTERISTICS (DIMENSIONS, WEIGHT, AND CUBE) FOR TRANSPORTABILITY OF MILITARY VEHICLES AND OTHER OUTSIZE/OVERWEIGHT EQUIPMENT (IN TOE LINE ITEM NUMBER SEQUENCE). This technical bulletin provides dimensions, weight and cube of military vehicles, vehicle-mounted equipment, and other outsize/overweight equipment. Staff, command and field organizations use these data for standard reference in developing and reporting unit movement data. The book is based upon FORSCOM's ECF.

The standards category will continue to focus on standardizing existing publications, databases, processes, algorithms, etc. currently in use by the deployment M&S community. Some of these products are as follows:

- Cargo Loading Algorithm. This algorithm simulates loading of cargo vehicles with unit cargo. It can also be used to load other transportation assets, such as containers.

- Deployment Planning Guide (MTMCTEA Reference 97-500-5). This guide lists the transportation assets (railcars, aircraft, containers, etc.) needed to deploy Army units during a time-sensitive scenario. It combines equipment characteristics with current unit capabilities and produces generic, rapid planning deployment data.

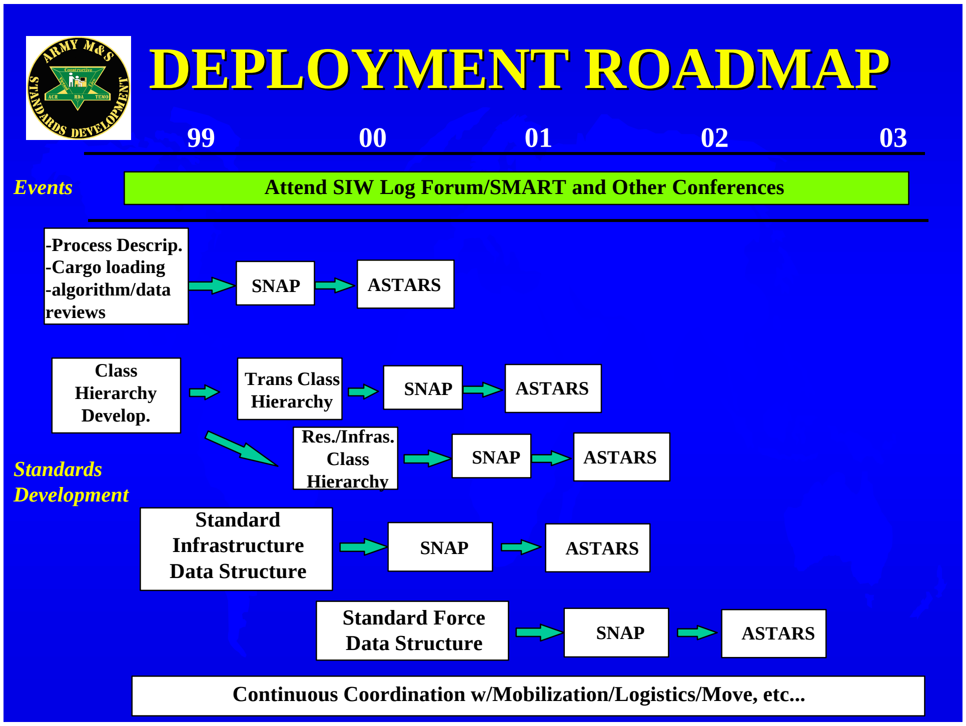
- Load Planning Database. The load planning data was incorporated into FORSCOM's Equipment Characteristics file (ECF) to support the Automated Air Load Planning System (AALPS). AALPS is designed to provide deployment commanders and planners of the joint community an automated means of producing "certifiable" air load manifests. AALPS is certified by the Air Mobility Command (AMC) for C-5, C-130, C-141, and C-17 load planning. In addition to AALPS, this load planning data is also used by the Integrated Computerized Deployment System (ICODES). ICODES uses this data for complex stow planning of ships. In addition to AALPS and ICODES, this data is also valuable to strategic planners in the deployment of equipment worldwide.

- Vessel Characteristics for Shiploading (MTMCTEA PAM 700-4). This publication contains vessel load characteristics for 150 US Flag dry cargo ships. It can be used to provide basic ship characteristics for ship loading and stowage operations.

PRIORITIES FOR NEXT YEAR

he focus for FY 00 will be on continual identification of existing products for standardization, including model and simulation algorithms/heuristics, publications, processes, and databases. We will also begin to focus our standards development efforts on defining standards for the representation of force deployment data and transportation networks.

ROADMAP


ARMY M&S STANDARDS DEVELOPMENT
DEPLOYMENT ROADMAP
99
00
01
02
03
Events
Attend SIW Log Forum/SMART and Other Conferences
-Process Descrip.
-Cargo loading
-algorithm/data
reviews
SNAP
ASTARS
Class Hierarchy Develop.
Trans Class Hierarchy
SNAP
ASTARS
Res./Infras. Class Hierarchy
SNAP
ASTARS
Standards Development
Standard Infrastructure Data Structure
SNAP
ASTARS
Standard Force Data Structure
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ASTARS
Continuous Coordination w/Mobilization/Logistics/Move, etc...

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Annual Standards Category Report for FY00

DYNAMIC ATMOSPHERIC ENVIRONMENTS

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 attenuating 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. All these weather effects and impacts are in the Dynamic Atmospheric Environments (DAE) domain and are in harmony with the DoD objective representation of the atmosphere.

The DAE category does not explicitly cover terrain, but it influences terrain in so far as weather effects are concerned. For example, snow cover will change the surface albedo, the amount of rainfall will change the condition of the ground state thereby changing mobility; other examples may be found. Since target acquisition depends heavily on target and background signature propagation through the atmosphere and on diurnal heating effects, background signatures fall under the purview of DAE. Target signatures per se, however, are in the domain of the standards category of Acquire.

Consideration of the above leads us to the definition of the DAE category for modeling and simulation (M&S): those objects, algorithms, data and techniques required to replicate weather, weather effects and impacts, backgrounds, acoustics, and transport and diffusion of aerosols and battle by-products.

STANDARDIZATION REQUIREMENTS

The natural environment is important in determining the outcome of real battles. Included in this area are weather features (clouds, fronts and thunderstorms, etc.) and weather effects such as target contrast changes. Meteorological data and weather scenarios are becoming available through efforts such as the Defense Modeling and Simulation Office (DMSO) funded Environment Scenario Generator (ESG), the Master Environmental Library (MEL), and the Total Atmosphere and Ocean Server (TAOS). But converting these meteorological parameters and weather features into quantitative effects and impacts that are not computationally burdening for simulations is a difficult proposition.

Due to the dynamic range of atmospheric processes the DAE category must represent a requirement spectrum ranging from small-scale effects found in high-resolution models, such as scene visualization, to large-scale, low-resolution, aggregated effects, to correctly represent weather impacts. In the high-resolution area physics-based calculations, such as the Army Research Laboratory's (ARL) Weather And Visualization Effects for Simulations (WAVES), are needed to represent high fidelity natural and battlefield-induced atmospheric effects (e.g. smoke, illumination, rain/fog, transport and diffusion, etc.), but usually are available only at a high computational burden. To reduce this burden a scenario-specific natural environmental representation can be pre-computed or pre-scripted (if time-varying) for later real-time simulations. However embedded environmental processes include battlefield-generated clouds, from munitions, vehicles, agents and fires, whose location and time of introduction cannot be completely pre-scripted. They are event-driven, resulting from battle actions and combatant decisions and thus can only be partly 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.

While progress has been made in this area in recent years, notably in the DARPA Synthetic Theater of War – Synthetic Environments (STOW-SE) program, such efforts require dedicated hardware and pre-computed weather effects scenarios. The underlying models in these simulations are inherently computationally intensive. Engineering level line-of-sight propagation models from ARL's Electro-Optical Systems Atmospheric Effects Library (EOSAEL) and the Air Force Research Laboratory's MODTRAN, while fast, are still burdensome considering the playing area, the potential number of lines-of-sight between entities and the number of pixels needed to generate virtual scenes.

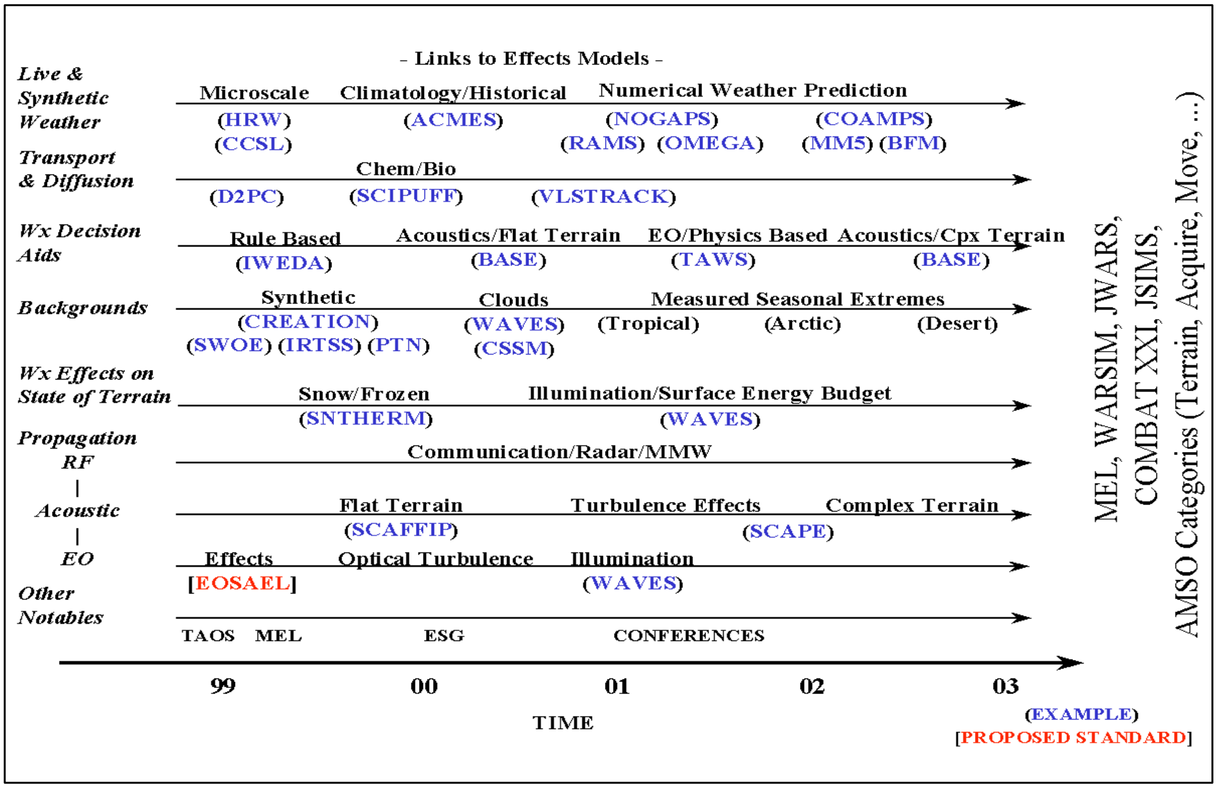
At the other end of the spectrum are the high level simulations that deal with aggregated units. These simulations simply can not afford to include detailed calculations for individual platforms and systems. Thus, a new approach is needed to include weather at a realistic level of fidelity and still maintain "faster than real time" simulation capability. Such an approach may exist in using rule-based programs, such as ARL's Integrated Weather Effects Decision Aid (IWEDA) model. This model, based in Army doctrine, provides color-coded matrix charts showing the impact weather has on various platforms, sensors and weapons systems thereby allowing for simple and fast assessments over large areas without a heavy computational burden. In order to provide for these disparate needs (of both high- and low-resolution simulations) DAE requirements, presented in priority order in Table 1, are general in nature.

Table 1. Dynamic Atmospheric Environments Requirements

- PROVIDE FUNDAMENTAL ENVIRONMENTAL MODELS FOR
- Identify Requirements for Standard Atmospheric Scenarios
- Provide Methodologies for Determining Consistent Data sets for Environmental Effects Models
- Provide Standardized Databases for System Performance Analysis

OBJECTIVES

In concert with these requirements the DAE category has the objectives of identifying fundamental gaps in atmospheric M&S, ingesting live meteorological data and real-time forecasts into simulations. Additional objectives include the development of: fundamental dynamic environment databases to support M&S; standard synthetic natural environment scenarios and backgrounds; and standard tools to facilitate weather impact decision aids and system performance analyses. Models that currently exist or are under development that will satisfy these objectives are embodied in the Dynamic Atmospheric Environments category roadmap (figure 1).



ACCOMPLISHMENTS AND ASSESSMENT

Assessment

Modeling efforts leading to the development of standard algorithms in the DAE area are, as might be expected, strong in some areas and in need of additional effort in others. In FY99 three EOSAEL models were approved as standards in the DAE category: the climatology model CLIMAT, the aerosol propagation model XSCALE, and the smoke model COMBIC. Additional information about these models may be found in the ARL technical report “Army Modeling and Simulation Standards for Dynamic Atmospheric Environments: CLIMAT, COMBIC, XSCALE,” ARL-TR-1834, July 1999. DAE AMIP projects, which include the FY98 Modeling of the Ground State in Winter Environments (GSWE) and the FY99 Light Scattering for Wargames and Target Acquisition (LSWTA) and 3D Static Environments and initialization (3DSE), are discussed below along with other additional areas where progress has been made this past year.

Teaming arrangements for the Dynamic Atmospheric Environments category include members from ARL, the Army Space and Missile Defense Command, the Cold Regions Research Engineering Laboratory (CRREL), and the AMTEC Corp.

Accomplishments

ARMY MODEL IMPROVEMENT PLAN (AMIP)

FY98: 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 was to address the issue of predicting the state of the ground (surface temperature, snow cover, snowmelt, and freeze/thaw depths) by utilizing CRREL's SNTHERM energy balance model. The methodology investigated the sensitivity of the ground state to different flux model initializations, including a semi-empirical model, a plane parallel model, and ARL's Atmospheric Illumination Module (AIM). 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 were inter-compared, including a comparison with measured ground state information.

Background

It is a well-established fact that the state-of-the-ground is driven in a large part by downwelling solar and IR fluxes. Models developed to predict the state-of-the-ground for Army operations depend critically on these fluxes for initialization. Unfortunately, these fluxes are not routinely measured parameters as is the case with more common meteorological parameters like temperature, relative humidity, etc. Therefore, indirect methods must be utilized to generate the required flux initialization information for state-of-the-ground models. Predicted ground temperatures were compared by using the SWOETHERM thermal model initialized with different solar flux schemes. These initialization schemes used solar flux values measured during the Smart Weapons Operability Enhancement (SWOE) field programs, and calculated solar flux values from Shapiro's semi-empirical model, a plane parallel model (MODTRAN), and ARL's AIM Model.

Variations in the level of spatial and temporal variability in the surface temperature and solar loading represents clutter. This clutter can degrade the performance of weapon systems. The performance impact on infrared systems is a direct consequence of this variation in the surface temperature and this variability affects systems operating in other spectral regions. For example, variations in the solar loading can cause variations in the physical characteristics of snow that can have a significant effect on active radar systems. With the recent emphasis on distributed models for synthetic scene generation, and the development of segmentation techniques that facilitate the distributed use of one-dimensional models, it is imperative that models are developed to provide the spatial and temporal variability of environmental parameters that drive the energy budget models used to predict the state-of-the-ground.

Results/Findings

The response of the surface temperature to different solar flux initialization schemes was investigated keeping all other environmental parameters constant. It was determined that for clear skies all schemes resulted in nearly identical surface temperatures. Thus, a semi-empirical model like Shapiro's has the advantage of computational speed. For partly cloudy and cloudy skies, only the AIM model mimicked the spatial variability observed with the solar flux and the resulting spatial variability in the surface temperature. The Cloud Scene Simulation Model (CSSM) was used to determine the spatial variability of the clouds. The cloud distributions were then used by AIM to produce the variations of the surface solar loading. CSSM also has the capability to produce the temporal variations in the cloud fields for short periods of time. Thus, it would be possible to use CSSM and AIM to produce the temporal and spatial variations in the solar loading. Models like AIM frequently incur a large computational burden. In order to reduce the computational burden associated with AIM several new procedures were implemented and investigation of additional techniques that can be used to reduce the model runtime will be continued. Distributed energy budget models used to predict the state-of-the-ground for the virtual depiction of the battlespace require distributed environmental parameters for initialization. Many of these parameters can be obtained from mesoscale models like MM5 or databases associated with programs like IMETS. However, none of these models or programs provides distributed solar or infrared flux, a key initialization parameter of energy budget models. Models like AIM linked to CSSM, or for that matter any model that provides information on the spatial and temporal distribution of atmospheric conditions, can be used to provide the spatial and temporal distribution of radiative fluxes. In addition to exploring techniques to decrease the run time of AIM, the potential use of AIM to generate distributed infrared fluxes should be explored.

Based on the measured solar flux and surface temperatures from the Yuma, AZ, SWOE field program it was found that the surface temperature for this semi-arid climate varied by several degrees for two measurement sites separated by approximately 100 meters for partly cloud skies. The measured solar fluxes varied by a factor of up to two, depending on the cloud conditions. Similar variations occurred during the Grayling, MI field programs. A surface temperature change of approximately 4 degrees centigrade over a period of approximately 12 minutes was recorded at a single site during Yuma, AZ, field program. The corresponding change in the total solar flux was approximately 500 W/m^2. Overcast sky conditions also produced similar variations in the surface temperature and the total solar flux. These variations were attributed, in part, to variations in the cloud thickness (cloud optical depth). Thus under most sky conditions, variations in solar loading were shown to produce spatial and temporal variations in temperature, which influences infrared signatures of background features.

FY99: Light Scattering for Wargames and Target Acquisition (LSWTA)

Light scattering from atmospheric aerosols affects the ability of a sensor operating in the visible to acquire targets. This effect, also known as path radiance, is embodied in wargames and target acquisition models as the sky-to-ground ratio (SGR). The SGR can vary from 0.2 for snow to 25 for forested conditions; accurate SGR determinations are needed to assure a high confidence for target acquisition ranges used in wargames and Test and Evaluation. Three existing models, all developed by ARL/BE, currently exist. One in TRAC's CASTFOREM, one in MICOM's Battlefield Environment Weapon System Simulation (BEWSS), and an in-house research grade code. The AMSO standards category of Acquire has requested a standard code. To accomplish this CASTFOREM's and BEWSS's legacy models are being compared with the AIM research grade code. A new model is being developed by extracting relevant portions from the legacy models and incorporating these with improvements determined from the research grade code and advances in the literature. This will result in a final model with fewer limitations and improved accuracy. This model, along with documentation, will be provided to both MICOM and TRAC. Potential also exists for application to NVESD's sensor performance model, ACQUIRE. The final model will also be proposed as a standard in the standards categories areas of Dynamic Atmospheric Environments and Acquire.

FY99: 3D Static Environments and Initialization

The operational Army operates in a 4-D environment. This places upon the modeling community a need to provide simulations in a spatially realistic 3-D environment. Typically the source of environmental data such as temperature, wind speed and direction, humidity and level of turbulence is a database, which generally contain values at a point or perhaps along a line. Such information is not adequate to realistically portray the environment, its variability or its effects. This effort will improve and combine existing techniques/models to produce a complete static 3-D description of the environment based on input from typical data sources.

OTHER ARMY EFFORTS

Weather Tactical Decision Aids

Weather tactical decision aids (TDAs) come in two flavors: rule-based and physics-based. Rule-based TDAs are constructed though rules which have been collected from field manuals, TRADOC centers and schools, and subject matter experts. Physics-based TDAs employ physics calculations that have their basis in theory or field measurements.

Tri-Service Rule-Based Weather TDAs

The Army's Integrated Weather Effects Decision Aids (IWEDA) is being adopted as the model for rule-based weather impact decision aids for all the services. A rule-based decision aid provides a general framework based on lists of "if-then-else" rules and pre-established critical weather thresholds for moderate or severe impacts. The Air Force, Navy and Army, with concurrence from the Marine Corps, are now collecting weather impacts using this common format, and the current database of hundreds of rules are expected to expand to several thousands of rules. The Army IWEDA is designed for the Army Common Hardware/software and DII/COE as part of the Integrated Meteorological System (IMETS), the C4I weather system currently fielded and being improved for the Army First Digitized Division.

Physics-Based Weather TDAs

Physics based tactical decision aids, as distinct from rule-based decision aids, perform detailed performance calculations for specific systems. Tri-service models for electro-optic propagation, such as the Tri-Service Target Acquisition Weather Software (TAWS) and models for acoustics are being linked to rule-based TDA's to provide more detailed effects and quantitative information.

Rule-Based Weather Impacts for M&S

The rule-based approach to weather impact decision aids is general enough to cover a broad range of weather effects and simple enough to be executed very rapidly. Initial translation of weather TDA's from qualitative "red-amber-green" impacts to quantitative "penalties and consequences" for use in simulations is being performed by JWARS as an implementation of IWEDA.

Live and Synthetic Weather

Various numerical weather prediction models of interest to the Army are being compared using common initialization and ground truth data sets. The Army's BFM, Navy's COAMPS, Air Force's MM5, Colorado State University's RAMS, and other specialized weather forecasting models are being compared by branches of ARL's Battlefield Environment Division. By using common inputs and for comparison against actual weather, the Army will be able to identify which models are best under various meteorological conditions and hardware/software constraints.

Microscale modeling (HRW)

The High Resolution Wind (HRW) model (see the FY98 AMSO standards report, DAE section, for more information on HRW) has been extended to include the effects of canopies. The effect of vegetation to the overall Canopy-Coupled Surface Layer (CCSL) flow patterns is analogous to the effect of varying terrain heights. This approach to handling the effects of vegetative canopies on the flow has been quantified and validated against a number of field trials. Likewise the canopy method for treatment of the urban domains does not include the effects of individual buildings, but does provide the influence of the urban terrain on the large-scale flow. The CCSL technique allows the up and down scale linkage between flows from mesoscale weather models and the CFD flows in and around buildings. As an AMIP project (see 3DSE above), these 2-D surface layer models are currently being extended to three dimensions. The original HRW model was designed to be viably operable on minimum input data. An improvement which will provide the ability of the HRW model to be partially dynamic and be applicable to larger domains has been initiated.

Transport & Diffusion

The SCIPUFF model, which uses an internal second order turbulence closure scheme to improve the effects of local atmospheric effects on dispersion, has undergone additional validation by the Defense Threat Reduction Agency. The model, currently driven by interpolated data from large domain (mesoscale) is currently being linked by the FY99 AMIP project (3DSE) to surface layer wind models to increase the effects of terrain on near surface transport and to include the local effects of surface features on diffusion. This linkage will provide a very high (100 meter) resolution capability for M&S transport and diffusion capability but will not carry with it the normally high overhead associated with high-resolution meteorology. The integrated product will be available in FY00.

Acoustics

Scanning Fast Field Program (SCAFFIP)

The Scanning Fast Field Program (SCAFFIP) is an ARL 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 frequencies to predict the propagation conditions around the location of a sensor. The FFP is a one-way solution to the acoustic-wave equation originally developed for underwater sound propagation predictions. The Scanning Fast Field Program (SCAFFIP) calculates an attenuation table with range and frequency for a given geometry and meteorological profile. The attenuation table is compatible for use by acoustic sensor performance models such as the Battlefield Acoustic Sensor Integration System (BASIS) and the Battlefield Acoustic Sensor Evaluator (BASE). BASE will be a versatile Unix-based acoustic decision aid the first version of which is under development and will be available by the end of FY00. The geometry profile is required because of the angular dependence of the sound speed; that is the wind direction is related 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.

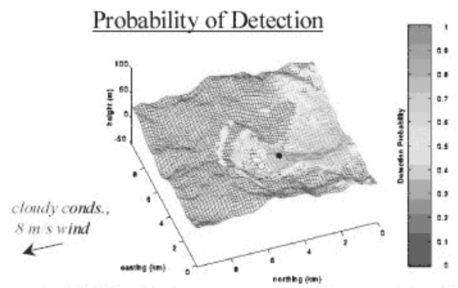


Figure 7: Probability of Detection for a fixed, ground-based sensor (circle)

Scanning Parabolic Equation (SCAPE)

The Scanning Parabolic Equation (SCAPE) model is an atmospheric acoustics propagation model incorporating the same effects as SCAFFIP. It is based on the Green's Function Parabolic Equation (GFPE) with the added ability to scan multiple frequencies to predict the propagation conditions about the location of a sensor. The GFPE is a reformulation of the Split-Step Parabolic Equation model used in underwater acoustics. SCAPE is currently under development by ARL with the first version due in FY00. SCAPE will also calculate an attenuation table with range and frequency compatible with the sensor performance models such as BASIS and BASE. This model will allow for the incorporation of turbulence and terrain effects (figure 2). Scattering from atmospheric turbulence will enhance signal levels at acoustic sensors located in refractive shadow zones where very low signal levels are expected. A version of the model including turbulence will be available by the end of FY00.

Acoustic Battlefield Aid (ABFA)

The Acoustic Battlefield Aid (ABFA) is ARL's prototype acoustic decision aid tool developed under MATLAB. ABFA performs realistic calculations of probability of detection, direction-finding resolution, spatial resolution from acoustic array networks, and other sensor performance metrics relevant to Army applications. It demonstrates ARL's unique capability to assess environmental effects on Army acoustical systems. ABFA also incorporates turbulence effects on acoustic sensors in addition to a simple model for the effects of terrain. The developments being made in ABFA are being transitioned to BASE.

Representational Resources Integration Experiment (RRIE)

The RRIE was a Tri-Service collaboration under the auspices of the Executive agents for Terrain, Air and Space Natural Environment, and Oceans. Several experiments were performed this past fiscal year: one of these experiments investigated the effects of mesoscale model grid size on entity level simulation results using ModSAF. The objective of this experiment was to examine how changes in atmospheric conditions, caused by varying the spatial resolution of a numerical weather prediction model, affect the dispersion of screening smokes deployed for protective cover. The impacts of terrain effects at different resolutions caused changing predictions of wind speed and direction, which were used to simulate smoke screen effects. Different wind conditions resulted in changes in the effectiveness of smoke and different rates of munition expenditure by attacking forces.

Weather and Atmospheric Visualization Effects for Simulations (WAVES)

High-Level Architecture (HLA)

WAVES is being integrated with the Total Atmosphere Ocean Server (TAOS) (see the FY98 Standards report, DAE section, for more information on WAVES). This integration will allow HLA federations to have an ability to access the complex three-dimensional data produced by WAVES. Integration with TAOS will also demonstrate that the APIs being developed are sufficient to allow alternate HLA interfaces.

Bio-Detection

Additional work is ongoing evaluating delectability of biological aerosol clouds in near-, mid-, and far-IR wavebands. This has required creating a high-spectral resolution aerosol optical properties database for use in WAVES. This additional data will also be available for hyperspectral and other analysis.

Paint The Night

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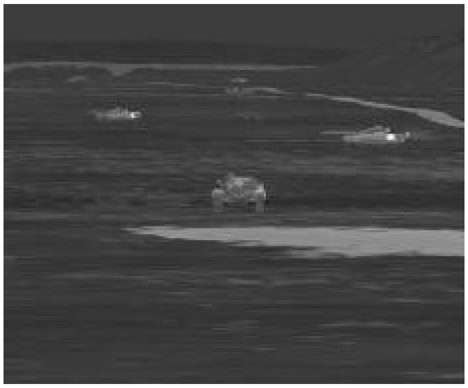

Figure 3: Battlefield Scene

Figure 4: Battlefield Scene with White Phosphorus added

Fu ... Integrati

Th ... gy Direc ... ld,
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commanders to better understand the battlefield and possible environmental impacts of their missions. Additional research will be performed to examine different styles of presentation and their effectiveness.

Atmospheric Optical Turbulence

A model (CN2) has been developed to allow a quantitative assessment of atmospheric optical turbulence. CN2 calculates vertical profiles of C_n^2 for near earth environments. The algorithm uses surface layer gradient assumptions applied to two levels of discrete vertical profile data to calculate the refractive index structure parameter. Model results can be obtained for unstable, stable, and near-neutral atmospheric conditions. The CN2 model has been benchmarked on data from the REBAL 1992 field study. The model will be added to EOSAEL in the near future.

Virtual Dirty Battlefield

The virtual dirty battlefield provides virtual smokes and obscurants modeling capability which can be integrated into synthetic scene generation of infrared battlefield scenes/scenarios. It is being developed by MRDEC, ARL, NVESD, US Navy, and Industry to support all phases of laboratory and field testing programs (primarily for imaging infrared sensors) where realistic dirty battlefield scenes/scenarios are required. It also has application to training, mission readiness (direct support testing) as well as mission rehearsal.

This capability utilizes the “emissive smokes” model created at MRDEC and also makes use of the EOSAEL COMBIC model as well as the ARL developed STATBIC model. These smoke and obscurant models represent natural and man made aerosols typically found in the dirty battlefield environment, and were selected as a result of a comprehensive market survey. Examples are shown in figures 3 and 4.

Clutter Statistics of Wet Snow Cover Measured with an FMCW Radar (32–35 GHz)

Snow-covered terrain represents a high-clutter environment for radar sensors. Because of the spatial and temporal variations in snow-cover properties, radars operating in a winter environment can encounter varying clutter statistics. Measurements have been initiated to determine the reflectivity characteristics of snow-covered terrain using an FMCW radar operating at 32–35 GHz. The relatively high bandwidth allows resolution of the dominant scattering mechanisms in a snow cover and allows investigation of the effect of frequency averaging on clutter statistics. Initial analysis is limited to wet snow cover where surface scattering is the dominant scattering mechanism. Typical backscatter results from a wet snow cover are illustrated in Figure 5.

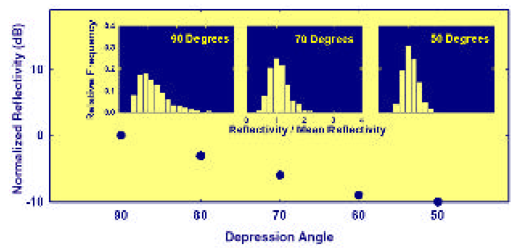

Figure 8: Refractivity characteristics of a wet snow as a function of depression angle obtained with a FMCW radar operating a 32-36 GHz bandwidth

For a wet snow cover, a 10-dB reduction in reflectivity can be expected as the radar depression angle decreases from 90 to 50 degrees. The width of probability density function (PDF) normalized to the mean reflectivity will also decrease as the depression angle decreases. (The width of the normalized PDF will increase as the radar bandwidth decreases because of reduced frequency averaging.) For wet snow, the frequency-averaged PDFs were successfully fitted with Rayleigh statistics and successive convolutions of Rayleigh statistics. The analysis of clutter statistics from dry snow cover will be complicated by the volume scattering contributions from individual snow grains as well as the reflections from layers within the snow cover.

Janus Combat Simulations with Cold Environment Effects

In the past, the Army has had no capability to conduct a simulation of combat in an environment that treats cold weather effects. To address that deficiency, CRREL formed a partnership with the Simulation Lab of the Systems Engineering Department at the United States Military Academy at West Point, New York. In this cooperative effort, Janus software is being modified to handle selected winter environment effects. This includes the effects of snow cover on target/background signatures and the effects of cold environment atmospheres, including airborne snow, on the performance of sensor systems.

Synthetic Physics-Based EM Scene Generation Problem

Terrain, vegetation, and weather effects present a complex, highly variable background for IR and MMW target seekers and IR viewers. This is especially true in the presence of snow and frozen ground. Captive flight tests are expensive and can account for only a limited range of conditions. DoD requires cost-effective methods for incorporating the complexities of the battlefield environment into training, planning, and weapon system development.

CRREL researchers have integrated field testing, physics-based modeling, and image rendering techniques to generate IR and MMW synthetic scenes (see Figures 6 and 7). Through the Smart Weapons Operability Enhancement Program (SWOE), a terabyte of IR and MMW validation images that span both winter and summer conditions have been assembled. An IR scene generation capability has been implemented and validated through the Office of the Secretary of Defense Joint Test and Evaluation Program. Physics-based

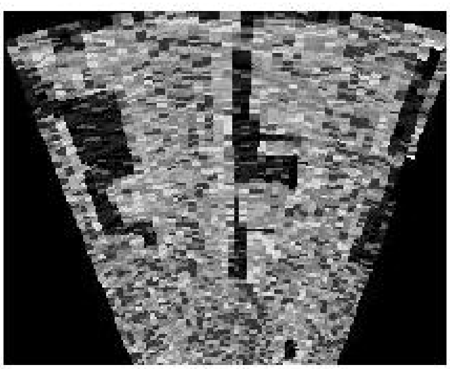

Figure 6: MMW Scene

Figure 7: IR Scene

MMW models of snow and soil processes have been coupled and distributed over test areas at high spatial and temporal resolutions. Predicted signatures have been rendered into scenes, which are comparable to measurements from captive flight tests. These maturing technologies can support training, planning, and weapon system development at a variety of levels. Applications include building all-weather databases for Distributed Interactive Simulation applications, selecting conditions for live training, and constructing look-up tables of smart weapons performance under winter conditions.

PRIORITIES

The priorities for next year include the continuing education of users and developers in the methodologies, processes and procedures for DAE. This will be accomplished through documentation, presentations, and tutorials. The need for standard weather scenarios, the improvement of run times for physics-based models, and the inclusion of fast running weather impacts algorithms for aggregated simulations are high priorities for the DAE category. Other priorities in the DAE category are presented in table 2.

Table 2: DAE Priorities in the Near, Mid, and Far Time Frame

FY	Projects
Near	WARSIM Weather Effects
Near	Acoustics for COMBAT XXI
Near	Icing Prediction Model
	Areas
Mid	Emissive Smokes
Mid	Urban "Canyon" Winds
Mid	Weather for Embedded Training
Mid	Weather Integration into JCDB/M&S
Mid	Remote Sensing Analysis Models
Mid	Forest Effects on Acoustic Sensors
Far	Atmospheric Effects for MOUT

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Annual Standards Category Report for FY00

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 FDB Working Group consisted of representatives from TRADOC, STRICOM and industry. The FDB contribution to the SCC program focuses on the simulation development processes that are independent of the simulation application. Initial implementation of the proposed FDB paradigm would be focused on developing guidelines and models for four new simulation developments -- WARSIM 2000, JSIMS, JWARS, , OneSAF, and others that follow. 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 and the information products that describe Land Component functions, validated by the user, and stored in a standard way for the use and consistent understanding of simulation developers.

STANDARDIZATION REQUIREMENTS

The FDB Standards Category will address the following:

- development of standard information templates for use by the Army user and simulation developer;
- development of a process that captures validated and traceable standard descriptions of the behaviors, components and characteristics of the Army domain,
- development of policy and procedures for managing Army repository data, models, and algorithms for simulation developers and users through a seamless knowledge repository for current and future simulations and models,
- formation of liaisons between major Army simulation programs and other Standards Categories to encourage use, and updates;

- Standardization of a front end analysis methodology and tool for simulation development;
- Exploration of 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 FDB SCC has worked with the Logistics SCC to develop information models and a validation process for these products on the FDB.

Working closely with DMSO and JSIMS, the FDB SCC Team has found and shared common interests with the MSRR, JCMMS and DMSO's Conceptual Model of the Mission Space (CMMS). The standard information models (templates) have become the standard within the JCMMS IPT to support the development of JSIMS. The processes developed for the capture and storage of FDB products in a repository are being worked collaboratively with the DMSO's CMMS initiative to become a single standard across DoD.

The FDB process for knowledge acquisition and validation has been approved by the DUSA(OR) as a standard, setting a precedent for developing a standard simulation development process.

Attendance at the AMSO Army M&S Standards Workshop on 3-6 May permitted an in-depth review of the FDB category's goals and objectives for the next 4 years. Discussions with other SCCs provided key information for all parties concerned to see where collaboration could bring better standards for the Army. The FDB SCC Team also presented an overview of the development of WARSIM to the workshop.
The goal is to promote the use of the FDB process, develop a standard simulation development process including knowledge acquisition and knowledge engineering tools, incorporate identified Army standard algorithms/data, facilitate the development and validation of algorithms where standards do not yet exist, and facilitate model and code module reuse.

PRIORITIES FOR NEXT YEAR

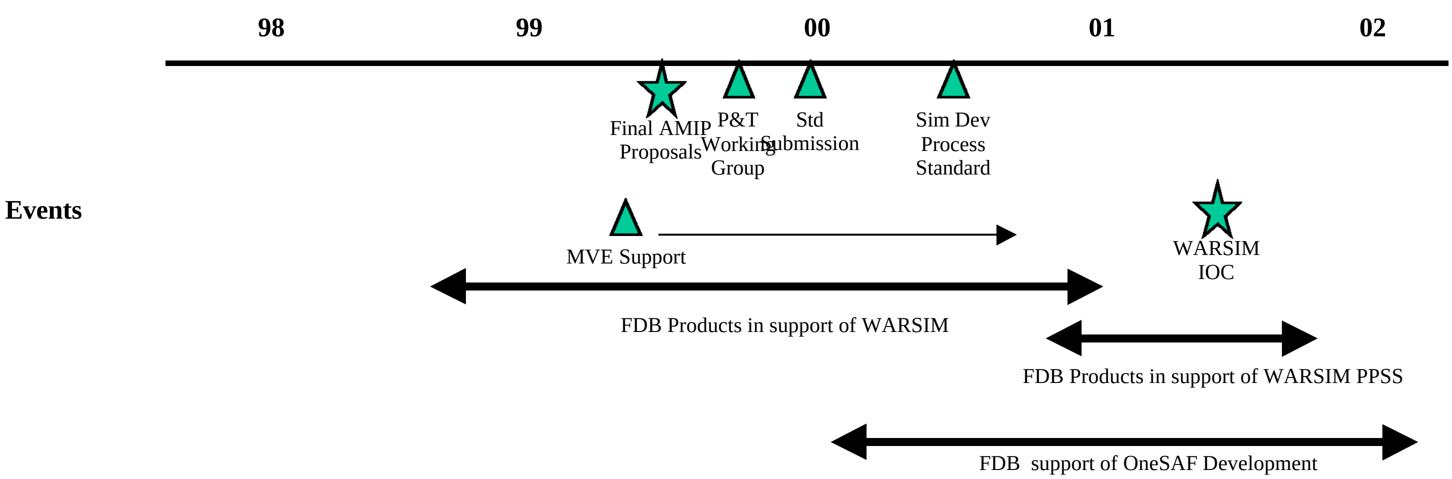
Continuing with the current WARSIM 2000 and JSIMS requirements, the FDB SCC Team will nominate the algorithms developed for WARSIM as standards, develop new repository methods which are accessible and useful to other categories to share their data, models and algorithms, and initiate a classified repository initially for use by WIM developers. Further collaborative efforts are also planned to enhance modeling and simulation development. To continue addressing the FDB SC charter, AMIP proposals will be nominated to:

- Formalize the modeling and simulation development process as well as develop an on-line set of tools that provides the developer with an automated method to assist the M&S development process.

- Develop policy and procedures for managing Army repository data in the FDB. Investigate ways to update FDB products based on publication of FMs, ARTEPS, and TOEs, using automated means.

- Develop a standard methodology for incorporating changes to force structure, tactics, doctrine, techniques, and procedures that occur during the development life cycle process, into the M&S development process.

ROAD MAP



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Annual Standards Category Report for FY00

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 (algorithms, processes) 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 – Logistics Description of the Battlespace
10 - Services
11 - Supply - Classes II, III (Pkg), & IV (Construction Material)
12 - Finance
13 - Stockage
14 - Supply - Classes VI and X
15 – Facilities

Approval of the products developed by the Logistics Standards Category Committee resides with the principal proponent for that function. These are known as the voting committee:

Commander QMC&S
Commander ORDC&S
Commander TC&S
Commander SSC
Commander AMEDD
Commander CASCOM

ACCOMPLISHMENTS AND ASSESSMENT

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

a. Review of algorithms. All the Logistics algorithms have been posted in the AMSO Standards Nomination and Approval Process. The committee and its voting members are using this web-based tool to track, validate and vote on algorithms suggested for consideration as new Army M&S standards. The algorithms posted were obtained from the OPLOGPLN, CSSCS, FASTALS, FMs or other approved sources. All the Logistics algorithms have been reviewed or are in the process of being reviewed for inclusion as standards. Medical algorithms are on hold pending revision.

b. Algorithms have been identified/developed for the following areas-

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

c. Example Algorithm:

Class I – Water
Quantity of Water by Unit: This algorithm computes the quantity of water assets (in gal/day) required to support unit src(I). Quantities are expressed to the nearest whole number.

Algorithm 1

QTY Water (src(i)) =PERS(src(i)) ALLOW water (PAR)1

For example, the number of gallons of water required to support a helicopter company [src=01387A200] is 321 gallons/day, calculated as follows:

QTY Water (01387A200) = PERS (01387A200) x ALLOW water (division, arid) = 27 x 11.9

= 321 gallons/day

d. The following is a summary of the logistics category's status on key actions of interest.

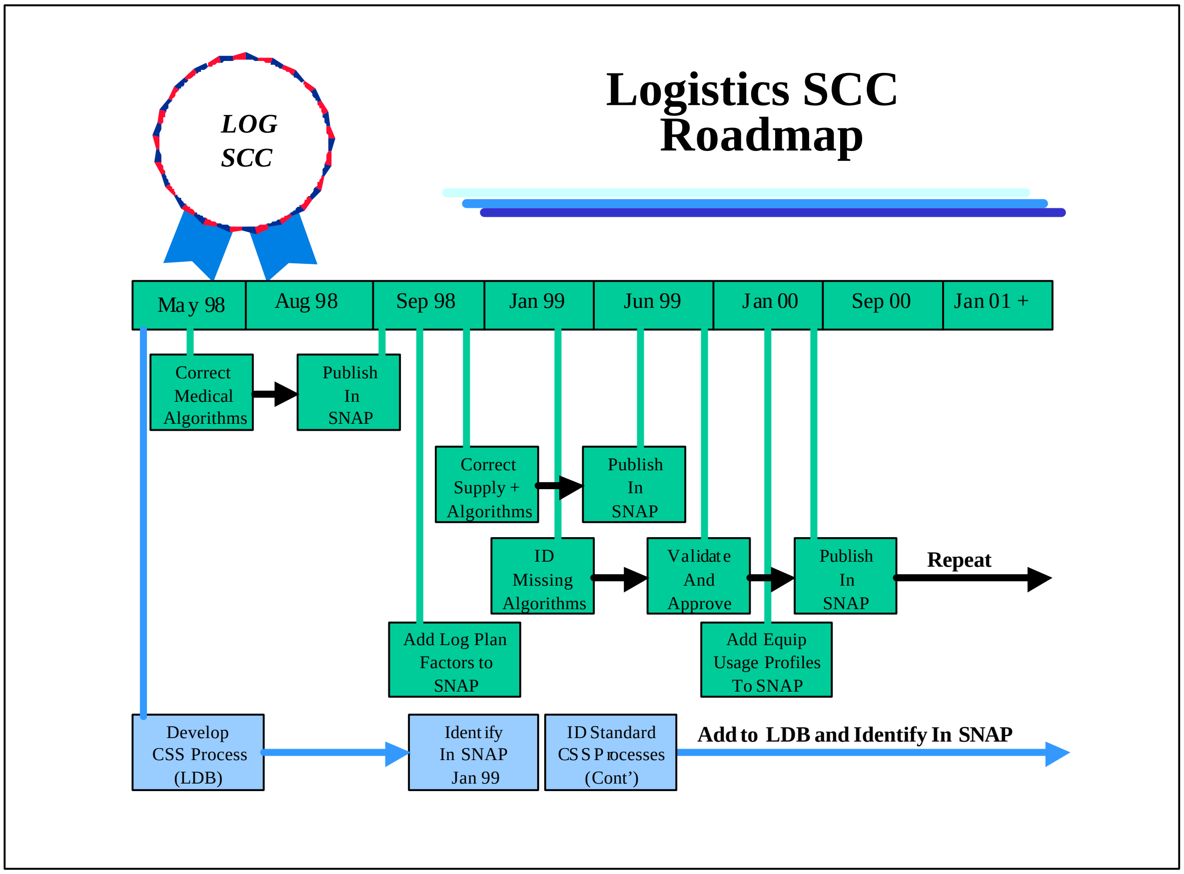
Action	Status
Establish Category and Definition	Complete
Define Requirements	Complete
Develop Standards (Phase 1)	Complete
Develop Standards	Continuous
Achieve Consensus	In progress, continuous
Obtain Approval	
Class I - Food and Water	Approved
Class II - Clothing and equipment	Reached consensus
Class III – Bulk and packaged	Reached consensus
Class IV – Construction materials	Reached consensus
Class V – Ammo	Reached consensus
Class VI – Personal demand	Reached consensus
Class VII – Major end items	Reached consensus
Class VIII – Medical Supplies & blood	On hold pending review
Personnel	In staffing
Stockage levels	Reached consensus
Medical – Casualties, hospital beds Patient rates, evac rates	On hold pending review

PRIORITIES FOR NEXT YEAR

New efforts for the upcoming year will focus on getting the current version of the Equipment Usage Profiles (EUP) entered and approved as a standard. The EUP is an extensive database, which predicts the utilization of each fuel-burning piece of equipment by its location on the battlefield, type of owning unit and combat phase or posture. Target date is 3rd Quarter, FY00.

The Logistics Standards Category Committee, in its 1999 meeting, recommended two AMIP proposals. The first in priority was a proposal for the development of a standard CSS object package for entity-level Army M&S. The second project called for development of a real-time interface between CSSCS and HLA compliant logistics models.

ROADMAP


LOG
SCC
Logistics SCC Roadmap
May 98
Aug 98
Sep 98
Jan 99
Jun 99
Jan 00
Sep 00
Jan 01 +
Correct Medical Algorithms
Publish In SNAP
Correct Supply + Algorithms
Publish In SNAP
ID Missing Algorithms
Validate And Approve
Publish In SNAP
Repeat
Add Log Plan Factors to SNAP
Add Equip Usage Profiles To SNAP
Develop CSS Process (LDB)
Identify In SNAP Jan 99
ID Standard CSS Processes (Cont')
Add to LDB and Identify In SNAP

Annual Standards Category Report for FY00

MOBILIZATION/DEMOBILIZATION

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 the 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 installation's 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 (i.e., 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 de-processing (reverse SRP), movement to permanent address, REFRAD.

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

STANDARDS REQUIREMENTS

- Standardize algorithms, objects and techniques for modeling mobilization and demobilization.

- Provide linkage of mobilization models and simulations to real time data bases.

- Ensure commonality with strategic deployment modeling objects and algorithms.

ACCOMPLISHMENTS AND ASSESSMENT

FY99 accomplishments of the Mobilization/Demobilization Category consisted primarily of M&S development in different areas of mobilization modeling. Each of the following projects supports the Army M&S Master Plan October 1997 M&S Objective 4: "A comprehensive set of standards that facilitates efficient development and use of M&S capabilities," and specifically Sub-Objective 4-3: "Comprehensive set of standards for modeling Army operations and physical phenomenology." While neither of the following projects was funded by AMIP in FY99, both involved work concerning the mobilization functional area and work toward standards development.

- Development of the Mobilization Capabilities Evaluation Model (MOBCEM), which models mobilization activities from Home Station (HS) to Port of Embarkation (POE), continued during FY99. Phase I of three phases of development has been completed and Phase II is in progress. Phase II will complete the Army version of MOBCEM and Phase III will incorporate the mobilization processes of the other services. MOBCEM will be an analytical tool which will fill the pre-deployment void in end-to-end modeling systems. The model will provide the capability to simulate mobilization operations and analyze theater capabilities and shortfalls in connection with major force structuring studies. It will also allow for mobilization analysis of capabilities and issues independent of the theater combat models.

- The FORSCOM Mobilization and Deployment Capabilities Assurance Project (MADCAP) Integration Management Initiative (MIMI) allows operational planners to analyze availability of units for onward movement and collective load on Power Projection Platforms/Power Support Platforms (PPPs/PSPs) in a variety of resource categories, i.e., ranges, housing, SRP, etc. MIMI resides under Sun Solaris 2.5.1 and Oracle 7.1.6. It is part of the Global Command and Control System (GCCS) within FORSCOM HQ. MIMI will have to comply with DII COE guidance to continue to be part of the GCCS. High Level Architecture (HLA) compliance for a prototype is completed and full compliance is underway. Also, the MIMI NT version is available.

  In addition, a Joint partnership to improve the deployment process with a MIMI/Joint Flow and Analysis System for Transportation (JFAST) merger is being developed. This will provide rapid development and assessment of Time Phased Force Deployment Data (TPFDD) requirements. When completely merged, the resultant product will be fully compliant with the Department of Defense HLA, and will meet requirements for full integration into the GCCS. This merger will provide a more rapid and precise assessment of unit readiness and validation, quick analysis of PPP/PSP capacities and installation out-loading, marshalling area and port throughput capabilities, transportation mode/source selection and allocation for best fit to each contingency, ability to rapidly reconfigure forces to meet fast changing requirements, and ability to quickly assess alternative deployment strategies with a stop/start function.

Other category accomplishments included the approval by the category's senior reviewers of the first two standards for the category. These standards, both mobilization policy documents, were as follows:

- The "FORSCOM Mobilization and Deployment Planning System (FORMDEPS)"

- The "TRADOC Mobilization and Operations Planning and Execution System (TMOPES)".

Two other draft standards were submitted through the Standards Nomination and Approval Process (SNAP) system, but were not yet ready to go through the approval process.

- The first was the "Army Mobilization and Operations Planning and Execution System (AMOPES)." This document is classified and was not able to be sent out for review to the senior reviewers because of an incorrect classification marking. This problem is currently being corrected and the document will undergo review and voting when corrections are completed, some time during FY00.

- The second was entitled "Standards Development for Mobilization Processing," which is a project that will produce a set of mobilization standard templates for Training/Warfighting Centers, CONUS Replacement Centers (CRCs), and Ports of Embarkation (POEs) mobilization activities. This project was funded by AMIP in August 1998 but fell on the cut line, lost the funds when AMSO took cuts to the program, and regained the funds in late FY99. Standards produced by this project will undergo the review and voting process during FY00.

PRIORITIES FOR NEXT YEAR

As stated above, at least two draft standards for the category are planned to go through the review and voting process during FY00. Those are the "AMOPES" and the "Standards Development for Mobilization Processing."

Additional draft standards may be produced or worked toward during the coming year if AMIP funding is approved for the proposed "Army MOVES" project. This project would produce a standard reporting format for PPPs/PSPs to report required mobilization data and a standard information architecture for the system to be used by mobilization planners and analysts.

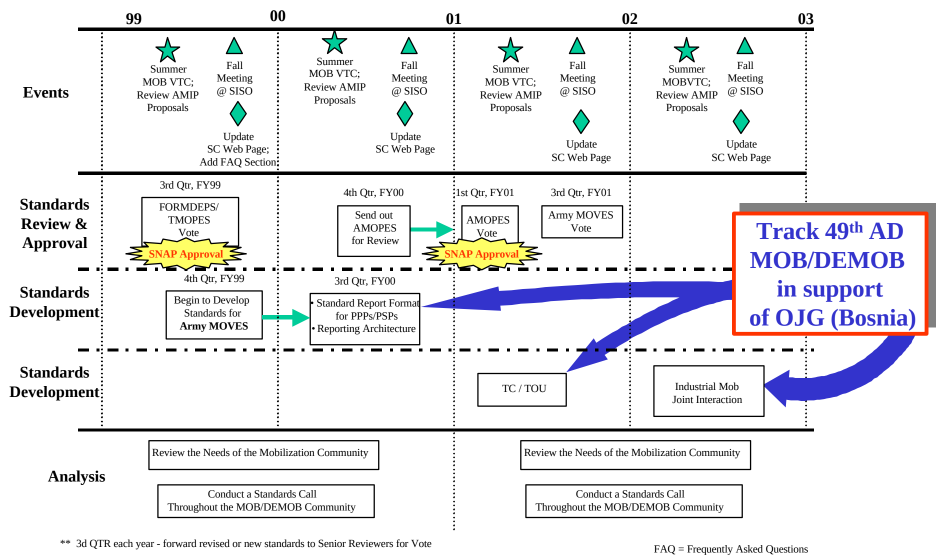
ROADMAP

The roadmap for the Mobilization/Demobilization category is shown in the figure below. Recurring events are shown across the top band of the chart. These include a summer category meeting or VTC for refining and finalizing AMIP funding proposals and the fall SISO meeting.

The middle bands of the chart depict events dealing with standards development. Shown are draft category standards flowing through various stages of the standards development process. Also included are events involving participation in category-related activities, such as support to an actual mobilization, review and analysis of the results of the mobilization, and possible standards development based on the analysis. These events will involve the participation of various organizations represented on the category team.

The band across the bottom of the chart depicts a periodic review of the needs of the mobilization community, including a standards call to the community. This is to ensure that the standards category remains up-to-date on the requirements related to mobilization/demobilization and M&S, and that the needs of the community at large are represented in the category's work towards standards development.

MOBILIZATION/DEMOBILIZATION CATEGORY ROADMAP



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Annual Standards Category Report for FY00

MOVE

STANDARDS CATEGORY DEFINITION

The MOVE Standards Category encompasses the objects, algorithms, data and techniques necessary to replicate activities that influence land force platforms/units and personnel movement across the battlespace within a theater of operations. It also addresses mobility and counter mobility as an engineer function, suppression (as a mobility degrader), formations and dispersion.

STANDARDS REQUIREMENTS

Land force platform and personnel movement (to include unit movement)
Mobility and countermobility as engineer functions

- Suppression effects on movement
- Dispersion and formations

ACCOMPLISHMENTS AND ASSESSMENT

- The NATO Reference Mobility Model (NRMM), Version II, was approved as a standard for representation of single vehicle ground movement.

- Completed FY 98 project *Air Battle Algorithms – Air Platform Movement*. The study addressed modeling required for air platform movement capabilities, identified deficiencies, and recommended requirements. This work is reflected in the standard submission SRD-00134.

- Completed FY 98 project *Standards for Engineer Mobility and Countermobility Operations in Modeling and Simulation*. Results provided an aggregated obstacle standard for engineer mobility and countermobility representation in theater-level M&S. This work is reflected in the standard submission SRD-00120.

- Submitted standards for *SRD 00124: Automated Mobility Corridor Determination, SRD 00125: Opposed/Unopposed Movement Rates for BD/BN, SRD 00135: Unit Route Planning.* The standards for *Automated Mobility Corridor Determination* and *Opposed/Unopposed Movement Rates for BD/BN* were not derived from Army Model Improvement Projects but were submitted from the community based on existing research products (GOTS). Unit Route Planning standard will be useful to the WARSIM and OneSAF programs in particular.

- Began FY99 project, *The Influence of Vehicle Geometry on Maneuverability Within the NATO Reference Mobility Model, AMIP-99-MOVE-03.* This project will develop maneuver relationships with increased sensitivity to unique vehicle attributes that will provide enhanced prediction capabilities of NRMM in off-road maneuver operations. The project will positively impact the acquisition community, large-scale force modeling and research. The Heavy Equipment Transporter Program Managers Office, for one, will benefit directly from these modifications to NRMM.

- Began FY99 project, *Development of Aggregation Standards for On-Road/Off-Road Logistical Movement in Theater-Level Warfare Simulations, AMIP-99-MOVE-04.* This research will result in a recommended standard method of logistical network aggregation for theater-level simulations. This project directly supports the JWARS program and has resulted in interested for reuse from the broader M&S community. Funds were also leveraged from the JWARS office for developmental support in this effort.

- Two spin-off standard nominations have resulted from the AMIP-99-MOVE-04 project: (a) global categorization method for network capacity and (b) pass rate standards based on characteristic factors.

- Expanded Standards Category membership to reflect the spectrum of the movement community within the MOVE Team. Members were added from PEO Aviation, USA Armor Center & Fort Knox, US Naval Surface Warfare Center – Marine Corps Program Office, USA Special Operations Forces, and USA Engineer Research and Development Center – Cold Regions Research and Engineering Laboratory. Previous representation included USA Materiel Systems Analysis Activity, USA Aviation Center, and USA Engineer Research and Development Center – Geotechnical Laboratory.

- Experienced active participation from the Standards Category membership on the MOVE Panel at the 1999 AMSO M&S Standards Workshop. Activities included adding MOUT as a MOVE focus area replete with challenges.

- Significantly improved MOVE Home Page on the World Wide Web and implemented procedure for posting and downloading documentation that further described the standards submissions. This resulted in increased participation from the community regarding standards review and development.

PRIORITIES FOR NEXT YEAR

The FY00 standards development priorities focus on algorithms for gap and obstacle crossing, rotary wing movement, movement during night and vision-obscured operations, and aggregation effects. It is expected that standards for these areas will be developed during the next year. The MOVE Standards Category initiatives support Objectives 2 and 4 as outlined in the October 1997 Army Model and Simulation (M&S) Master Plan.

Standards for FY99 projects are expected to be approved during FY00:

(a) standard for aggregation of segments in transportation networks and (b) standard algorithms enhancements for NATO Reference Mobility Model (NRMM) long-trailered vehicle systems maneuver. Additionally, two spin-off standards from the project, *Development of Aggregation Standards for On-Road/Off-Road Logistical Movement in Theater-Level Warfare Simulations, AMIP-99-MOVE-04,* will be proposed to the community to address a global characterization of transportation networks related to capacity and a standard methodology for calculating throughput based on the standard NRMM.

The FY00 proposal nominations address standards for gap and obstacle crossing, rotary wing movement, and movement in night and vision-obscured operations. Gap and obstacle crossing standards will serve development of programs with regard to assessment of mobility potential, river crossing analysis and time to conduct the operation, and route selection. Standards for night and vision-obscured operations will allow for accurate portrayal of the warfighter's capability for movement potential at night or in fog or smoke. Air movement algorithms will result in standard algorithms to effectively depict rotary wing capability for use in systems evaluation for example.

Progression of submitted standards through the SNAP will be tracked by MOVE during the upcoming fiscal year. Verification and Validation issues will be addressed

ROADMAP

In accordance with the October 1997 Army Model and Simulation (M&S) Master Plan and the category near-term priorities, the top three MOVE Standards Category proposals were submitted for consideration for FY00 funding:

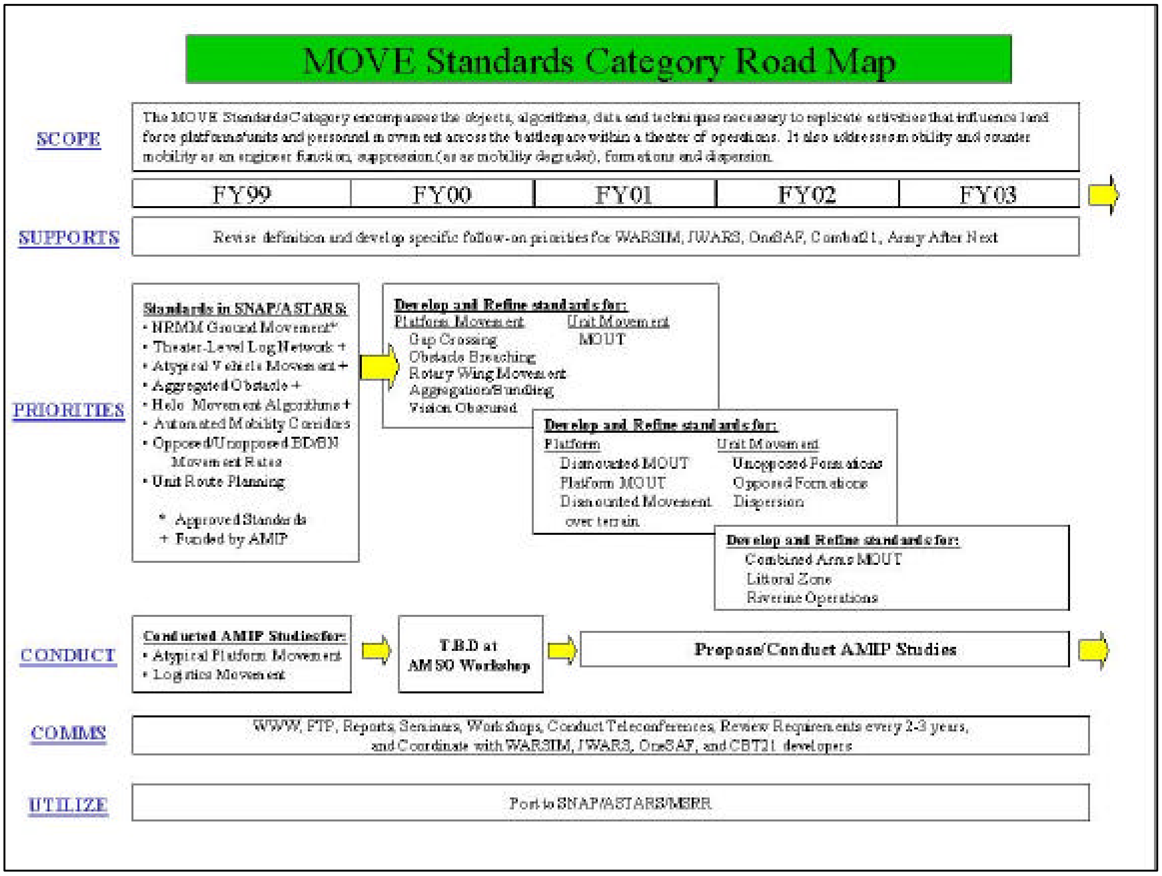
1. *Vehicular Mobility during Night and Vision Obscured Operations*: Current Army vehicle mobility models and the vehicle mobility algorithms in combat simulation models are severely limited in their ability to portray night and vision obscured movement operations. This research will provide the data and algorithms necessary to

overcome this deficiency. Executing Agencies: US Army Engineer Research and Development Center and the Night Vision & Electronic Sensors Directorate.

2. *Air Battle Algorithms –Rotary Wing Algorithm Study*: This study is a follow-on to the FY98 study, *Air Battle Algorithms – Air Platform Movement.* This study will expand on the previous results with a more comprehensive comparison of model fidelity within each category. The goal is to recommend the best model(s) for each requirement. Additionally, recommendations will be made for fixing identified shortfalls in the selected models. Executing Agencies: U.S. Army Materiel Systems Analysis Activity with PEO Aviation.

3. *Consistent Representation of Gap & Obstacle Crossing Operations:* Algorithms to characterize crossing or breaching are required for the full range of designs, to include rivers, antitank ditches, and point obstacles such as road craters and must incorporate vehicle characteristics, environmental parameters, and interference and/or geometry. Standards for integration across the spectrum of echelons will be produced, incorporating equipment, personnel, and time factors. Executing Agencies: US Army Engineer Research and Development Center and U.S. Army Materiel Systems Analysis Activity.

These proposed efforts support the development of standards identified by MOVE for the near-term. Coordination with other Standards Categories is considered essential in the execution of MOVE initiatives and will be carried out through teleconferences and meetings. A pre-meeting at a member site was held prior to the FY99 May AMSO M&S Standards Workshop and proved very beneficial. This activity is planned for FY00 as well. At the FY00 workshop, coordination/interaction between other Standards Categories, including SAF, TERRAIN, and LOGISTICS, enhanced resulting proposals and roadmap development. The roadmap for MOVE is shown below. Support to OneSAF, JWARS, JSIMS, WARSIM, COMBAT XXI, and Army After Next are central to the outlined progression. MOUT was identified as a challenging area with needed standards development to support M&S and the future force.



MOVE Standards Category Road Map
SCOPE
The MOVE Standards Category encompasses the objects, algorithms, data and techniques necessary to replicate activities that influence land force platforms/units and personnel movement across the battlespace within a theater of operations. It also addresses mobility and counter mobility as an engineer function, suppression (as as mobility degrader), formations and dispersion.
FY99
FY00
FY01
FY02
FY03
SUPPORTS
Revise definition and develop specific follow-on priorities for WARSIM, JWARS, OneSAF, Combat21, Army After Next
PRIORITIES
Standards in SNAP/ASTARS:
• NRMM Ground Movement*
• Theater-Level Log Network +
• Atypical Vehicle Movement +
• Aggregated Obstacle +
• Helo Movement Algorithms +
• Automated Mobility Corridors
• Opposed/Unopposed BD/BN Movement Rates
• Unit Route Planning
* Approved Standards
+ Funded by AMIP
Develop and Refine standards for:
Platform Movement
Gap Crossing
Obstacle Breaching
Rotary Wing Movement
Aggregation/Bundling
Vision Obscured
Unit Movement
MOUT
Develop and Refine standards for:
Platform
Dismounted MOUT
Platform MOUT
Dismounted Movement over terrain
Unit Movement
Unopposed Formations
Opposed Formations
Dispersion
Develop and Refine standards for:
Combined Arms MOUT
Littoral Zone
Riverine Operations
CONDUCT
Conducted AMIP Studies for:
• Atypical Platform Movement
• Logistics Movement
T.B.D at AMSO Workshop
Propose/Conduct AMIP Studies
COMMS
WWW, FTP, Reports, Seminars, Workshops, Conduct Teleconferences, Review Requirements every 2-3 years, and Coordinate with WARSIM, JWARS, OneSAF, and CBT21 developers
UTILIZE
Port to SNAP/ASTARS/MSRR

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Annual Standards Category Report for FY00

OBJECT MANAGEMENT

STANDARDS CATEGORY DEFINITION

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

- Consistent in their representation of object attributes/methods,
- Applicable to 90% of the M&S employing them,
- Accepted 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
- Explorations of methods for gathering, sharing, and storing metadata about standard objects.

ACCOMPLISHMENTS AND ASSESSMENT

The goal of providing standard objects for use by M&S developers is being addressed in two phases. The first phase is the development of a set of key standard object templates that address the fundamental entities and processes of Army simulation development. Once the key M&S object templates are designed, focussed primarily on the minimum essential methods associated with each object, a second phase will be initiated. This phase involves the identification of the standard Army algorithms associated with the standard object methods. The purpose of this activity is to provide the M&S developer with a pointer to the set of standard algorithms that would address the intent of the standard object method. Additionally, the activity will also review the standard output of the algorithms (public data) and define a standard attribute interface (nomenclature, definition, units) for the algorithm. In this way, simulations operating at comparable detail would be interoperable at the standard object level.

Over the FY99, the OMSC revised approved object standards, completed object designs, and initiated new object development that supports the first phase of object standardization. These activities include:

- Platform Object Updates. Based on the continual review of the Platform Object and the development of a Platform Object use case, the Platform Object was updated in the following manner:
  - The "aim" and "fire" methods listed in the Weapon Object were consolidated into the "engage_target" method as the former are internal actions that do not have to be shared with other objects.
  - The "get_Size" method in the Platform_Frame and Platform_Frame_Component was changed to "get_Signature" to more accurately describe its ability to represent multiple signature types.
  - The OMSC website Platform Object section was updated with these changes.

- Unit Object. Based on the continual review of the Unit Object, the Unit Object was updated in the following manner:
  - The "speed" and "direction" methods in Unit Object were consolidated in a "velocity" method.
  - The "look" method in the Intel Object was changed to "collect".
  - The OMSC website Unit Object section was updated with these changes.

- Location Object. This object consists of the Local Object and the LatLon Object. The notion of location is fundamental to most military simulations. There are numerous coordinate systems used in simulation, each appropriate for some simulations and not suitable for others. A common, abstract location object can foster interoperability among simulations that use different coordinate schemes. A draft object was presented at the May workshop and updated based on participant's comments. Three options for the Location Object were posted on the OMSC reflector with additional comments provided. The Location Report was re-drafted based on the community comments and will be posted again for review in Aug 99. It is anticipated that a senior reviewer vote will take place prior to the close of FY99.

- Data Collection Object: This object allows the M&S user to adopt data services that can be tailored to address unique study analysis data requirements. A report was drafted to define the object structure, methods, definitions, and use case. A draft object was presented at the May workshop and updated based on participant's comments. The Data Collection Object Report was drafted based on the community comments and will be posted on the OMSC reflector for review by Aug 99. It is anticipated that a senior reviewer vote will take place prior to the close of FY99. A draft Data Collection Object structure, definition, and report were posted on the OMSC website.

- Environment Object. An Environment Object was defined to represent the overall environment in which a simulation would transpire. The Environment Object is comprised of a Terrain Object, Atmosphere Object, Water Object, and Space Object.

The OMSC initiated development of the Environment Object and the object methods that are considered the minimum essential to represent terrain. A number of COMBAT XXI developed Environment Object methods, especially with respect to the Water Object, were adopted. While the Environment Object structure and definitions were agreed to by the OMSC at the May Workshop, comments from coordination with the Terrain SC via their reflector provided a number of comments that questioned the Terrain Object design in particular and the OMSC standard object approach in general. Further interaction and coordination with the Terrain SC are required before the Environment Object can move further through the approval process. It is anticipated that the first quarter of FY00 will involve discussions on the final form of the Environment Object.

- Behavior Object. Sophisticated modeling of combat requires simulations to provide model entities with the capability to react to induced stimuli as they occur. The OMSC developed a Behavior Object that defined the behavior actions necessary for simulations to model combat entities. This object includes the classification and integration of combat behaviors, from individual soldiers up to command level, into Army standard objects. A first draft report was written and discussed at the May Workshop. This draft was posted on the OMSC website. Comments, to include the development of a planning object, are being incorporated in a second draft to be submitted for review at the beginning of FY00.

- JCDB/OMSC Interaction: At the request of AMSO, the OMSC and the C4I Integration SC met several times to discuss whether alignment of the OMSC standard objects and Joint Common DataBase (JCDB) data model would benefit simulation integration. The two parties met at a joint session at the May Workshop and again at AMSAA on 13 July to discuss the issue. After an exchange of briefings and discussion of integration issues, the two groups agreed to hold a three-day meeting to go over the specifics of the OMSC object standards and the JCDB (soon to evolve into the Army Integrated Core Data Model (AICDM)). The purpose of this meeting is to further understand the content of the two approaches and identify ways, if any, in which the data model and object standard approaches can integrate to support M&S interoperability. The minutes of the 13 July meeting were posted on the OMSC reflector.

PRIORITIES FOR NEXT YEAR

The following are OMSC priority activities for FY00:

- Behavior Object. The OMSC will continue refinement of the Behavior Object that will emanate from a second draft of the Behavior Object report. After the OMSC reviews the updated draft, the report will be posted on the Command Decision Modeling SC and the Semi-Automated Forces SC reflectors for coordination and comment. This action is expected to take place in the first quarter of FY00 with continued development throughout FY00.

- Environment Object. In addition to the completion of the Terrain Object, the OMSC will continue development of the Environment Object by developing the Atmosphere Object, Space Object, and Ocean Objects.

- Mine/Minefield Objects – The FY00 AMIP proposal includes the development of a Mine/Minefield Object that addresses the representation of individual mines as well as the aggregate representation of a minefield.

- Features Objects – The FY00 AMIP proposal includes the development of Feature Objects that address the representation of point entities (e.g., well, watertower, antenna), line entities (e.g., roads, pipelines, railroads, trench), and area entities (e.g., cities/towns, clouds, ditches).

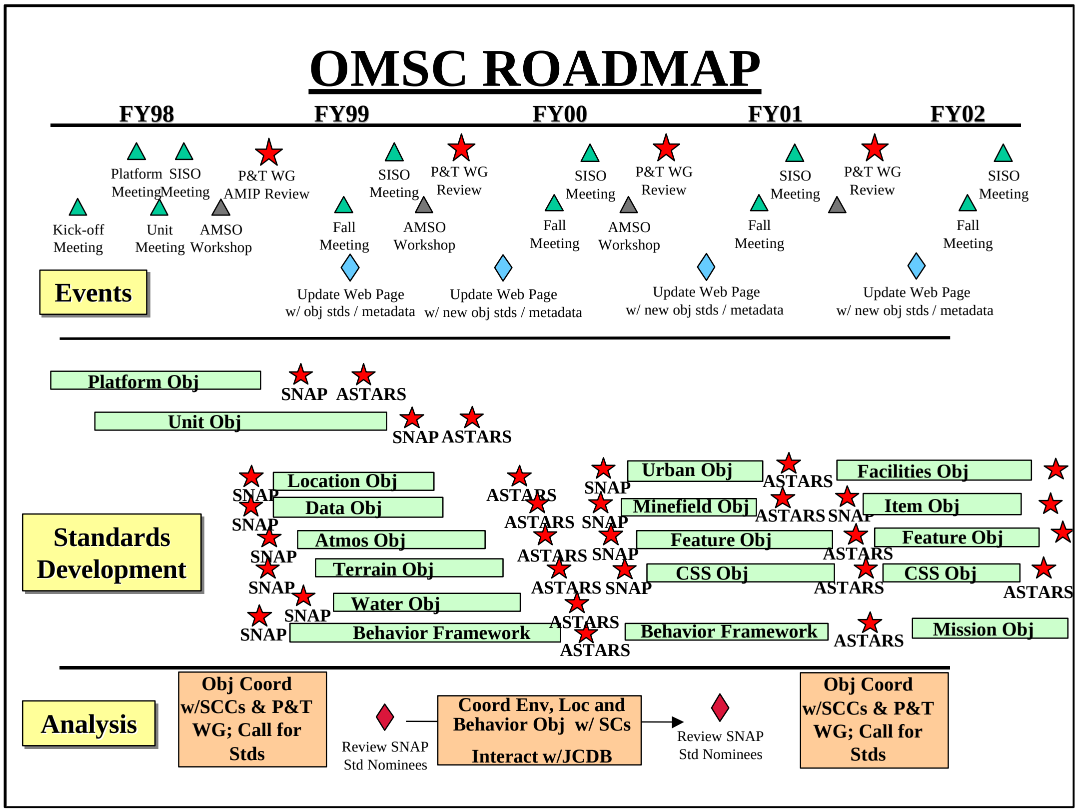
- Urban Objects – The FY00 AMIP proposal includes the development of Urban Objects that address objects within an urban area that would benefit from representation as an aggregate object, vs. collection of many objects, such as facilities (e.g., depot, stations, ports), massing (e.g., traffic, crowds) and buildings.

- Basic Object Model (BOM) – The FY00 AMIP proposal includes an exploratory investigation of the development of BOMs that represent basic object building blocks to support development of physics/engineering-type M&S.

- JCDB/OMSC Interaction: Continued interaction between the OMSC and the C4I Integration SC will take place to determine whether the OMSC can adopt portions of the JCDB data model to support standard object development and M&S interoperability.

- Updated Website. This activity consists of the continual revision of the OMSC website to list objects, object methods, object definitions, and standard algorithm references in an easily navigable manner as a reference point for M&S developers.

ROADMAP


OMSC ROADMAP
FY98
FY99
FY00
FY01
FY02
Kick-off Meeting
Platform Meeting
SISO Meeting
Unit Meeting
AMSO Workshop
P&T WG AMIP Review
Fall Meeting
SISO Meeting
AMSO Workshop
P&T WG Review
Fall Meeting
SISO Meeting
AMSO Workshop
P&T WG Review
Fall Meeting
SISO Meeting
P&T WG Review
SISO Meeting
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Events
Platform Obj
SNAP
ASTARS
Unit Obj
SNAP
ASTARS
Standards Development
Location Obj
Data Obj
Atmos Obj
Terrain Obj
Water Obj
Behavior Framework
Urban Obj
Minefield Obj
Feature Obj
CSS Obj
Behavior Framework
Facilities Obj
Item Obj
Feature Obj
CSS Obj
Mission Obj
Analysis
Obj Coord w/SCCs & P&T WG; Call for Stds
Review SNAP Std Nominees
Coord Env, Loc and Behavior Obj w/ SCs
Interact w/JCDB
Review SNAP Std Nominees
Obj Coord w/SCCs & P&T WG; Call for Stds

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Annual Standards Category Report for FY00

SEMI-AUTOMATED FORCES (SAF)

INTRODUCTION

SAF is a subset of computer generated forces (CGF), the more generic term for the manifestation of representations of actual or notional entities in a computer simulation. SAF are supported by a unique set of new technologies and contain unique characteristics that lend themselves to a conceptually wider set of applications than their predecessors. The SAF standards category (SC) contains a unique set of functions and requires/drives support from many of the other SCs. The SAF SC's function is to identify standards for its functions and coordinate its functional standards with the other SCs to provide Army M&S with SAF representations and behaviors that support Army requirements across the three domains (ACR, TEMO, and RDA).

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 human operators and/or 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.

ACCOMPLISHMENTS AND ASSESSMENT

AMIP-99-SAF-01 The Composable Behavior Standard Data Acquisition Project (Supported Standard Requirements: 1,2,3, and 4)

ACCOMPLISHMENTS: An initial primitive action list has been derived from the source of the concept for the project, CASTFOREM. Expansion of this set and validation by functional area is the next objective. This collaborative effort of TRAC and NSC was modified to accommodate the loss of the original NSC team member. The NSC will provide behavioral definitions and primitive actions for support of civilian play in M&S. This is a little more difficult and higher risk from the well-exercised combat engineer functions initially planned.

ASSESSMENT: The research was initially intended to be at the entity (SAF) level. Definition of a primitive action has proven more subjective and difficult to gain consensus than anticipated. What is apparent is the need to establish at least three types of primitive actions which parallel the degree of detail normally associated with aggregate, entity, and engineering level M&S. This effort will at least establish a baseline for use and common understanding when various M&S users speak on the subject. This project remains targeted at the entity level (e.g., OneSAF, COMBAT^{XXI} level).

AMIP-99-SAF-02 Modular Terrain for Entity Level Computer Generated Forces ModTerrain) (Supported Standard Requirements: 1,3, and 4)

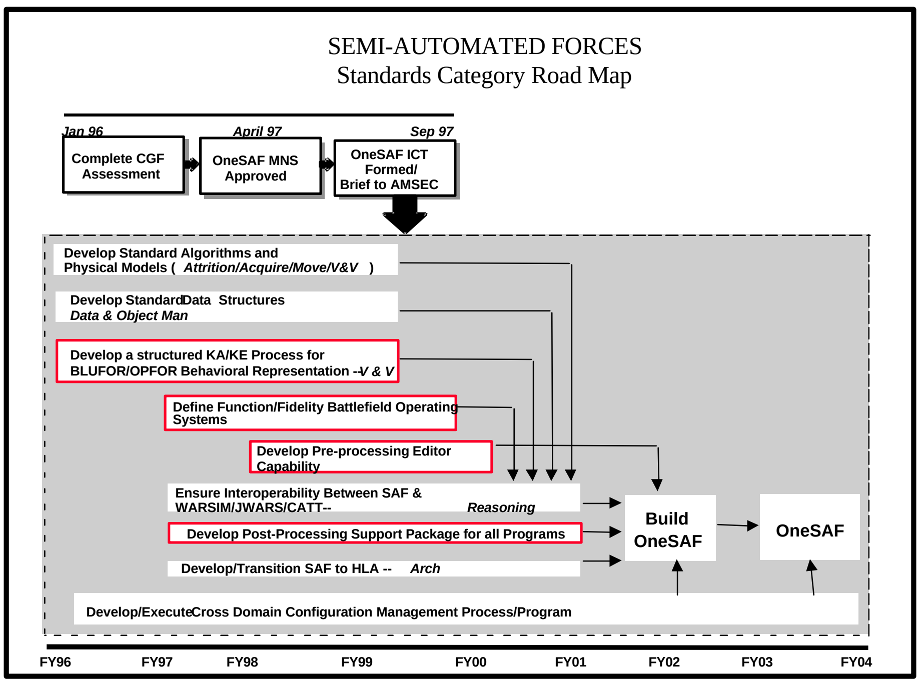
ACCOMPLISHMENTS: To date this research has produced: (1) a draft functional description and white paper which serve as the draft standard for the ModTerrain run-time terrain API specification; (2) a C++ prototype (ModSAF CTDB) run-time terrain module using the draft standard; (3) a Java prototype (generic terrain) run-time terrain module using the draft standard; (4) a conference paper prescribing the ModTerrain project; and (5) a masters thesis by an NPS student describing the project and the Java prototype.

ASSESSMENT: This research has progressed according to the implementation plan and is on track to meet or exceed all requirements. The research team will provide a standards nomination in September 1999. Community review and early prototyping have contributed significantly to the quality of the draft standards nomination and supporting documentation. The research team discovered that it is important to coordinate with related standards initiatives to leverage merging standards.

PRIORITIES FOR NEXT YEAR

1. Decompose SAF/CGF into component parts (terrain, data, etc) and tools (editors, data analysis, etc)
2. Identify components and tools supported by other SCs and the SAF SC.
3. Identify typical applications for SAF/CGF in each domain (RDA, TEMO, ACR).
4. Identify products from applicable SCs satisfying SAF requirements for typical domain applications.
5. Inform SCs of required products to support SAF functions and coordinate/monitor SC product shortfall development/exploration efforts.
6. Request from the M&S community SAF/CGF SC unique tried and proven state of the art functionalities for submission to SNAPS/ASTARS.
7. Request proposals for development of SAF solutions where current technology does not meet requirements.
8. Update the SAF roadmap to reflect the product of this year's research.

ROADMAP



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Annual Standards Category Report for FY00

SYSTEM DESIGN AND ARCHITECTURE

This report provides a status of architecture standardization efforts, including identification of significant progress made during the past year and standardization priorities for FY00.

STANDARDS CATEGORY DEFINITION

During the Standards Workshop this year, the group recommended that the category name and definition be modified to more accurately capture the intent of Architectural standards. The term architecture was felt to be too vague on its own and open to interpretation. Therefore, a new name System Design and Architecture was proposed to clarify the intent to disseminate binding standards for interoperability and share experiences with standard patterns for system design. Associated with the name change, a new category definition was also proposed:

The System Design and Architecture category addresses standards for the structure, relationships, and design principles/guidelines of the components of virtual, constructive, and live simulation systems from the Advanced Concepts and Requirements (ACR), Research, Development and Acquisition (RDA), and Training, Exercise and Military Operations (TEMO) domains.

STANDARDIZATION REQUIREMENTS

The proposed Army standardization requirements for architecture are:

1. Facilitate the interoperability (e.g., data distribution, interest management, time management, and model to model interaction) of all types of models and simulations.
2. Facilitate the reuse of modeling and simulation components within and between simulation systems.
3. Expose paradigms for design of the overall structure of different simulation systems.
4. Disseminate definitions of system design and architecture concepts and components.

ACCOMPLISHMENTS AND ASSESSMENT

For each of the architecture standardization requirements the following accomplishments were made during FY99. The assessment of these projects is that the Army and DoD are adequately funding technology related to system design and architecture so that standards can be developed. However, the sharing of experiences related to system design and architecture across and between Army organizations has not been occurring at a sufficiently aggressive pace.

Facilitate the interoperability (e.g., data distribution, interest management, time management, and model to model interaction) of all types of models and simulations

A. IEEE Standards Activity. Two HLA Standards have been nominated for IEEE standardization: the HLA Interface Specification V1.3 and the Object Model Template (OMT) Specification V1.3. Standards development groups have actively met to resolve comments to the proposed standards in preparation for IEEE balloting.

B. 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.

C. SIW. The SIW supports the entire Modeling and Simulation (M&S) community by embracing the DoD High Level Architecture. Historically, the workshop evolved from the DIS Workshop; however, the scope of the workshop now encompasses 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. Two SIW workshops took place during the past fiscal year, focusing on HLA.

D. Run Time Infrastructure (RTI). DMSO sponsors the RTI software development during the HLA evolution 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. Current development efforts are in two phases. RTI 1.x is a government-developed initial RTI build. RTI 1.3NG will be industry developed, using an open competitive design process. This RTI implementation will continue to comply with the 1.3 version of the specification. Like the 1.3 version, it will be distributed freely. There may be additional follow-on design efforts.

- RTI 1.x. Development of RTI 1.x was initiated at the time of the acceptance of the HLA baseline specification (September 1996). The first build (F.0) was provided within the first quarter FY97. It provided the majority of the RTI services specified in HLA Interface Specification 1.0. Documentation, installation support software and sample federate software is delivered with each release. RTI 1.3 (there is no 1.1 or 1.2) provides the full set of HLA services specified in the HLA Specification documents version 1.3 (see HLA Technical Specifications topic).

- RTI 1.3NG. RTI 1.3NG is a full implementation of RTI services based on competitive industry designs and development. The Phase I RTI 1.3NG software design contract began immediately following the HLA Baseline Definition in August 1996, and culminated in the award of a Phase II RTI 1.3NG software development contract to SAIC in September 1997. STRICOM has been the procurement agent for the design and development effort, and a technical advisory team, which includes representatives from various DoD user organizations, is supporting this activity. RTI 1.3NG supports HLA Specification 1.3 and is currently in beta test.

E. Object Management Group (OMG). The OMG is an industry consortium with over 800 members committed to "developing technically excellent, commercially viable and vendor independent specifications for the software industry." The OMG is perhaps best known for its development of the Common Object Request Broker Architecture (CORBA) standards. The Defense Modeling and Simulation Office has joined the Object Management Group as a Corporate member, to promulgate information about HLA to the larger industry based distributed software community. The OMG Board of Directors formally adopted the HLA Interface Specification v1.3 (service descriptions and OMG IDL API) as the Facility for Distributed Simulation Systems. This adoption by OMG is the first formal industry standards adoption of HLA. The Specification was submitted for standardization under OMG by the OMG Special Interest Group for Distributed Simulation (which a DMSO representative co-chairs with an industry representative). The OMG review process includes a series of reviews by the OMG architecture board, open comment by industry, endorsement by OMG domain body, vote by OMG members and finally, adoption by the OMG Board of Directors. This is a major milestone in the ongoing process to transition HLA to broad use in the DoD and industry in the US and internationally.

F. Joint Technical Architecture - Army (JTA-Army). The JTA-Army is the comprehensive set of standards required for Army and Joint interoperability. The Army responded to an Office of the Secretary of Defense (OSD) request by stating that the Army will implement the Joint Technical Architecture (JTA) through the implementation of the JTA-Army. The JTA-Army is a comprehensive set of standards for Army and Joint interoperability that is compliant with the JTA. This gives Army systems developers a single technical standards document to go to for the standards that need to be followed at all levels. The JTA-Army, Version 5.5, is the latest approved technical architecture for Army implementation. It was formerly titled the Army Technical Architecture (ATA). Version 5.5 was approved 23 DEC 1998 JTA-Army supersedes JTA-Army Version 5.0. Significant focus has been placed on merging the Technical, Operation, and Systems architectures together in the latest revision. The latest version, including migration plans, is available from the Army Digitization Office web page (http://www.ado.army.mil/Br&doc/docs/ata/Default.htm).

G. Joint Technical Architecture (JTA). The JTA provides DoD systems with the basis for the needed seamless interoperability. The JTA defines the service areas, interfaces, and standards (JTA elements) applicable to all DoD systems, and its adoption is mandated for the management, development, and acquisition of new or improved systems throughout DoD. The JTA is structured into service areas based on the DoD Technical Reference Model (TRM). The DoD TRM originated from the Technical Architecture Framework for Information Management (TAFIM) and was developed to show which interfaces and content needed to be identified. Standards and guidelines in the JTA are stable, technically mature, and publicly available. Wherever possible, they are commercially supported, and validated commercial off-the-shelf (COTS) implementations from multiple vendors are available. The JTA consists of two main parts: the JTA Core, and the JTA annexes. The JTA Core contains the minimum set of

JTA elements applicable to all DoD systems to support interoperability. The JTA annexes contain additional JTA elements applicable to specific functional domains (families of systems). These elements are needed to ensure interoperability of systems within each domain, but may be inappropriate for systems in other domains. JTA version 2.0 included a Modeling and Simulation annex. Version 2.0 was approved 28 May 1998 and draft version 3.0 was released for review 26 FEB 1999. Both versions are available from the JTA internet site (http://www-jta.itsi.disa.mil/).

Facilitate the reuse of modeling and simulation components within and between simulation systems

A. Conceptual Models. Although progress has been slow, the sharing of conceptual models between development programs has substantially increased. Through the Functional Description of the Battlespace, the knowledge acquisition data and associated conceptual models that were developed for WARSIM/JSIMS are being shared with others in the simulation development community including OneSAF and JWARS.

B. Federation Testing Tools. Getting heterogeneous simulations to interoperate in a distributed environment is no easy task. Testing is necessary to detect errors and ensure that each simulation in an exercise is on the page and can in fact interoperate with other simulations. Undetected errors can cause a range of problems such as: degrading fidelity and fair fight issues, causing simulations to crash, and forcing an exercise to be aborted. Three federation testing tools and services are available through STRICOM's Advanced Distributed Simulation Testing home page (http://www.ads-test.org/cgi/main.cgi). These tools are:

- Federation Test System (FTS) which is a testing environment providing process and tool solutions for High Level Architecture (HLA) Federation Testing.
  - DIS Test Suite (DTS) which is a compliance testing tool for Distributed Interactive Simulation (DIS).
- HLA Gateway which translates DIS PDUs to HLA Objects and HLA Objects to DIS PDUs.

Expose paradigms for design of the overall structure of different simulation systems.

JSIMS High Level Design. During this past year the JSIMS (and associated service/agency partner programs) experienced a significant redesign from a framework based architecture to an API based architecture. This process for making this change, along with the definitions of the new architecture, has been well described in several documents. The JSIMS Abstract Model (JAM) defines the content of a Joint command and staff training system in non-software terms. The Battlespace Abstract Model (BAM) defines the content of JSIMS in terms of the definitions in the JAM. The Data Interchange Model (DIM) defines the data that will be shared between simulation objects and how it will be passed. These documents can be obtained from the JSIMS web page (http://www.jsims.mil/alliance/library/library.html) or from PM WARSIM ((407) 384-3650) at STRICOM.

Disseminate definitions of system design and architecture concepts and components. Although no substantial progress was made in this area during the past year, several efforts (i.e., definitions of composability, approaches for interest management, definition and application of time advance schemes, and simulation system components for various types of systems) are planned for the near future.

Status of FY99 AMIP Funded Projects. No Architecture projects were funded through AMIP for FY99

PRIORITIES FOR NEXT YEAR

The Architecture Standards Category Team met at the Army Modeling & Simulation Standards Workshop on 3-6 May 1999. At the workshop, the team redefined the architecture requirements, revised the list of architecture shortfalls from FY99 based on the Architecture Roadmap, and recommended projects for FY00.

A. HLA Evolution 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. Study groups are frequently established to focus on specific issues related to the HLA. Their products are available at http://siso.sc.ist.ucf.edu.

B. Composability. A derived definition of modeling and simulation composability is the ability to create, configure, initialize, test, and validate an exercise by logically assembling a unique simulation execution from a pool of reusable elements in order to meet a specific set of objectives. Programs such as JSIMS, WARSIM, and OneSAF are studying the feasibility and issues associated with composing simulation systems to meet their individual objectives.

C. System Design Components. Emphasis needs to be placed on developing a common understanding of the components of simulation systems. A more common community wide understanding of simulation concepts such as interest management, time management and composition will help to facilitate interoperability and reuse.

D. SEDRIS. The Synthetic Environment Data Representation and Interchange Specification (SEDRIS) is intended to articulate and capture the complete set of data elements and associated relationships needed to fully represent a synthetic environment used as the basis for training or gaming. The definition of the Data Model is expected to support the full range of simulation applications (e.g., computer generated forces, manned, visual and sensor systems) across all environmental domains (terrain, ocean, atmosphere, space). In addition to providing a standardized representation method, SEDRIS will provide a standard interchange mechanism to pre-distribute environmental data and facilitate interoperability among heterogeneous simulations. This community-wide interchange mechanism will support the reuse of synthetic environment databases between disparate simulation systems.

ROADMAP

The Architecture Roadmap extends from FY99 to FY03.

AMIP Proposals. Three projects have been nominated for FY00 AMIP funding under the System Design and Architecture Standards Category. They are provided in descending order of importance to the architecture standardization process.

A. Reference FOM for Multi-Resolution Simulation. This project proposes the study of standard methods for linking simulations that operate at different resolution levels or fidelities. The project will define, within the context of the High Level Architecture (HLA), a reference Multi-Resolution Federation Object Model (MRFOM). The MRFOM will include class and interaction definitions that support ownership transfer of simulation objects and communication of command and control information between federates at different resolutions or fidelities. The project will demonstrate MRFOM by applying it to a new multi-resolution federation developed by linking prototype versions of WARSIM and OneSAF.

B. Implementation Independent Abstract Model for Wargames. Existing efforts to improve the realistic representations within military simulations have focused on conceptual models which describe the real world and software implementation which implement a subset of the real world description. Selection of which real world aspects to include in a given development effort has proven problematic. The Implementation Independent Abstract Model (I2AM) will provide a description of the content that should be considered when developing a military wargame (i.e., a constructive simulation) and provide an intermediate product between real world descriptions and software implementation that is readable and meaningful to both military subject matter experts and software developers.

C. Architecture Description Language suitable for Simulation Software Architectures. This project proposes to research the need for a standard Architecture Description Language (ADL) for the simulation community by researching existing ADLs to determine how well they describe the simulation related components of software architectures used in simulation. The project will also evaluate availability of tools to simulate the ADL specifications. As part of the evaluation, a description of a conceptual OneSAF architecture in an ADL will be created and evaluated using ADL specification to evaluate the performance modeling tools.

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Annual Standards Category Report for FY00

TERRAIN

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, weather, and cratering due to weapon effects. In contrast, static terrain does not change after a simulation has been started.

STANDARDS REQUIREMENTS

The standardization objectives of the Terrain category include:

1. Defining geospatial information content, resolution and accuracy requirements for developmental models and simulations.

2. Determining correlated terrain databases.

3. Determining standards for rapid terrain database generation.

4. Determining standards for representing dynamic terrain.

5. Determining a consensus based data exchange standard.

6. Encouraging use of standard repositories (SNAP, ASTARS, MSRR, &MEL).

7. Coordinating with other standards categories closely coupled with terrain.

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) programs. 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. 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, (6) database reuse, and (7) realistic soil and feature properties.

Accomplishments

The following AMIP, SIMTECH, and DMSO studies and projects were concluded in FY96:

> ***High Resolution Terrain Study.*** This study was initiated to answer specific questions concerning the impact of terrain resolution on data ownership, or the costs associated with the production, use, storage, and transmission of high resolution data. The study also sought to quantify the effects of high-resolution terrain data on battle outcomes in constructive models such as Janus, and virtual simulations like the Close Combat Tactical Trainer (CCTT).
>
> ***Synthetic Terrain Integration and Construction System Implementation Report.*** This study was initiated to develop a design concept for an integrated production system to generate Interim Terrain Data (ITD) and Digital Terrain Elevation Data (DTED) products. The recommendations from this study were intended to assist TEC's Operations Division (OD) in integrating its commercial hardware and software assets with an interface designed to lead terrain analysts through the creation and exportation of standardized data products needed to support M&S applications. Army Directive 93059360, Digital Topographic Data (DTD) Requirements for Army Modeling and Simulation (M&S), 13 Aug 93, challenges TEC to become a co-producer of ITD and DTED to support the Army M&S community. NIMA has recognized the same need for an off-line production capability based on Commercial Off-The-Shelf (COTS) hardware and software and has initiated a Distributed Terrain Data Test Bed Facility effort in conjunction with TEC OD and the Institute for Defense Analysis (IDA) to develop a STICS like prototype production capability.
>
> ***Neural Net Prototype to Generate M&S Terrain Databases.*** The purpose of this project was to develop a stand alone system based on rapid prototyping designs that integrates JPL artificial neural network technologies and image processing techniques to produce vector formatted terrain files (e.g., transportation, surface drainage, vegetation, and urban area delineation) from NIMA Arc Digitized Raster Graphics (ADRG). Due to the unexpected departure of two key JPL project scientists involved in this developmental effort, JPL was not able to complete the project and deliver the neural net software and final report to TEC for evaluation and testing in Aug 96. Despite this set back, Lockheed Martin/Loral has developed and marketed a similar product with the same functionality. Initial evaluations of this software package reveal it to be a robust product for rapidly converting raster map information into usable vector formatted terrain data.
>
> ***DIS Terrain Data Format Study.*** The purpose of this report was to provide descriptions and comparisons of existing and developing standard DTD and

Distributed Interactive Simulation (DIS) terrain data exchange formats in the context of general DIS community requirements for terrain data. An analysis of these formats was made to determine each format s key features and its ability to support the DIS community. Each format was examined relative to the support that it provides for each of the following key characteristics: metadata; topology, ranging from Level 0 (none) to Level 3 (full topology support); spatial organization and indexing; feature and attribute coding; text; composite features; integration and/or layering; multiple levels of detail; 3D data; 3D model behaviors; and, coordinate systems and datums. The results of this study identified key spatial data modeling and representation concepts provided by these formats which should be included in future synthetic environment data interchange standards.

Analysis of Digital Topographic Data (DTD) Issues in Support of Synthetic Environment Terrain Database Generation. The purpose of this report was to examine the use of DTD in the generation of synthetic environment terrain databases, with the goal of identifying enhancements to the current NIMA DTD formats and products that would facilitate the synthetic environment terrain database generation process. The report describes six synthetic environment terrain database generation systems, focusing on their use of current DTD formats and products; identifies a number of issues related to the use of DTD in synthetic environment terrain database generation; and describes a general framework for synthetic environment terrain database requirements, addressing mobility, sensor simulation, and terrain reasoning, as well as visual image generation.

The following AMIP, SIMTECH, and DMSO studies and projects were concluded in FY97 and FY98:

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, GID produced 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.

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 contains information on algorithms that reasonably model or simulate dynamic environment and terrain processes. TRAC POC: Ms. Susan Solick at solicks@trac.army.mil.

Line-of-Sight (LOS) Reuse Study. The goal of this TEC study was 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.

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.

Synthetic Theater of War (STOW) 97. STOW97 was an Advanced Concept Technology Demonstration (ACTD) jointly sponsored by DARPA and the United States Atlantic Command (USACOM). TEC's Topographic Research Division, formerly the Topographic Applications Laboratory, executed the SE STOW program, under the direction of DARPA's SE Program manager. The STOW program sought 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 included:

- ***Dynamic Virtual Worlds (DVW).*** DVW integrates 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.

- ***Dynamic Terrain and Objects (DTO).*** DTO integrates 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 are 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 employed 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 includes scatterable and standard emplaced mines and minefields, road craters, anti-tank ditches, obstacles, survivability positions, bridge demolitions, highway overpass demolitions, and railroad demolitions.

- ***Integrated Computer Generated Forces Terrain Database (ICTDB).*** ICTDB represents a new capability in terrain database representation. This new representation accommodates multiple data sources with integrated feature and elevation data.

Extended terrain feature attributes include attributes for weather effects. Multiple elevation surfaces, such as the ocean surface over the ocean floor, caves, tunnels, and buildings are supported. Aggregated features support maneuver by higher echelons. The ICTDB supports a global coordinate reference system is 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.

- ***STOW Terrain Databases (TDBs).*** The STOW program developed a suite of advanced TDBs that satisfy high, medium, and low fidelity requirements. STOW TDBs produced by TEC's Operations Division are available for reuse.

  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.

  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.

  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, DMSO, and NIMA-TMPO have initiated this effort to develop a consensus based standard interchange mechanism.

  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.

Model and Simulation Resource Repository (MSRR) Master Environmental Library (MEL). MEL is a sponsored distributed environmental data access system which allows users to search for, browse, and retrieve environmental data from distributed sources.

PRIORITIES FOR NEXT YEAR

Six Terrain category proposals were submitted in response to the FY00 call for AMIP proposals. The project titles and submitting organizations include:

Coordinate Transformation ToolKit for M&S Applications (SRI): Coordinate transformation computations are significant users of processing time in both distributed and stand-alone simulation. Proposal objective is to reduce the computational load and allow simulation of more entities.

Catalog of Algorithms Used for Dynamic Terrain Modeling (TRAC-WSMR): Proposal objective is to identify, categorize, and document all currently used dynamic terrain simulation techniques.

Accurate, Data-Compressed Terrain Representation by Non-Oscillatory Splines (ARO): Proposal will demonstrate that use of the non-oscillatory spline technique will provide more accurate and compact terrain and features.

Characterization of Vegetative Undergrowth to Improve Mobility and LOS Prediction for M&S (TEC/TRAC-WSMR/WES): A study to help characterize undergrowth vegetation and provide a more precise understanding of how it impacts mobility and LOS in Army M&S.

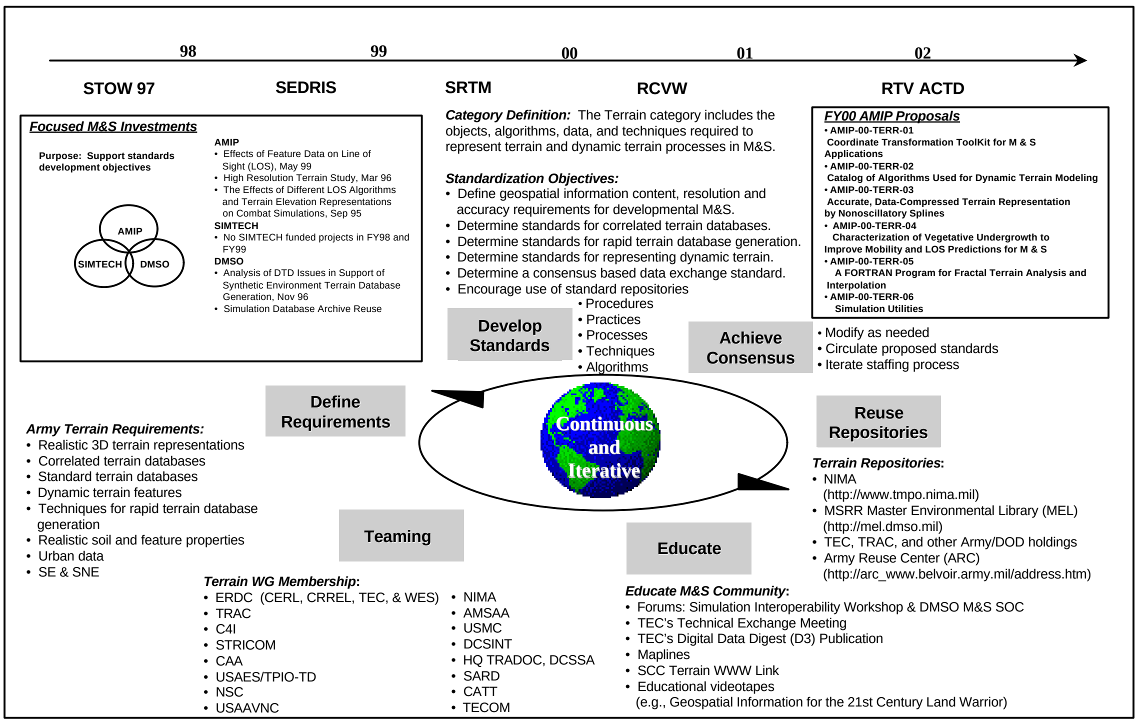
A FORTRAN Program for Fractal Terrain Analysis and Interpolation (AMSAA): Proposal will study whether fractal analysis and interpolation of terrain elevations files is a useful tool for categorizing terrain, enhancing the resolution of existing terrain, and creating synthetic terrain.

Simulation Utilities (TRAC-MTRY): This project will identify, locate, document and prototype terrain and other simulation utilities.

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 in May 1999. The top three proposals, as listed above, were nominated for Policy and Technology Working Group (P&T WG) FY00 funding consideration. These proposals will be briefed to the P&T WG in Aug 99, and recommended for funding.

ROADMAP

TERRAIN ROADMAP



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Annual Standards Category Report for FY00

VERIFICATION, VALIDATION, AND ACCREDITATION

STANDARDS 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.

Validation is the process of determining the extent to which the M&S adequately represents the real world from the prospective 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.

STANDARDS REQUIREMENTS

Establish and define standard verification, validation and accreditation processes.

Build verification and validation tools and guidelines.

Develop measures of effectiveness to identify key elements and establish validation tolerances.

ACCOMPLISHMENTS AND ASSESSMENTS

DoD Verification, Validation & Accreditation Technical Working Group (VV&A TWG):
The TWG continues to refine the Recommended Practices Guide and voted to
submit the revised DoD 5000.61 to the MSWG in June. The TST continues to focus on the development of the web-based recommended practices guide and VV&A report templates.

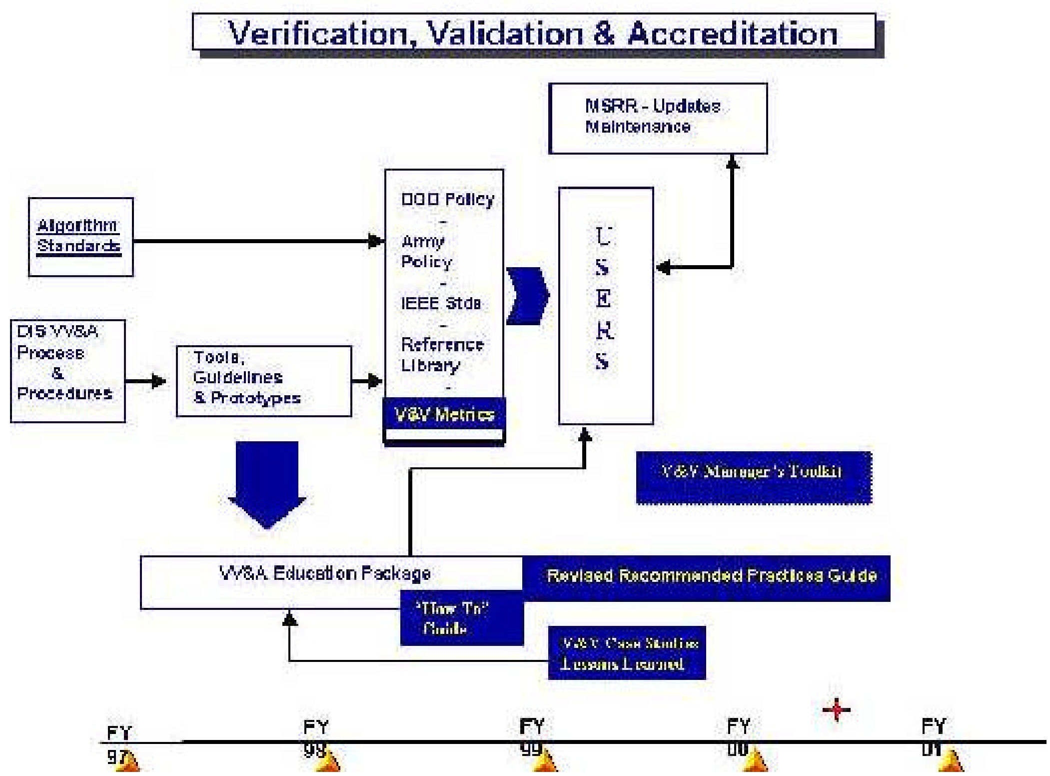
MORS sponsored SIMVAL 99 at Johns Hopkins APL on 26-28 January 1999 and was attended by 155 individuals interested in VV&A. Through plenary sessions and a series of group meetings, the workshop addressed several VV&A issues facing the M&S community. The workshop attendees were divided into three groups: Verification Technology; Validation Technology and Methodology; and Impact of Technology on VV&A Costs. A complete report on the proceedings can be found and downloaded from the MORS web site at www.mors.org.

Partial funding for the V&V Manager's Toolkit implemented the start of that project. The Toolkit will provide a largely automated process that, once used in the planning stage, migrates into the active management of the V&V project without requiring additional input or data. We are seeking additional funding to complete the construction and to build an on-line user's manual and tutorial.

PRIORITIES FOR NEXT YEAR

The priorities for this category will be the continued education of users and developers in the methodologies, processes and procedures for VV&A. This will be accomplished through documentation, presentations, and tutorials. Another high priority is the completion of the V&V Manager's Toolkit. It will support the planning and execution of all types of Verification and Validation programs ranging from IV&V to VV&A of unitary models and simulations (M&S) to HLA-based large-scale distributed simulations suitable for war games and national exercises. The V&V Manager's Toolkit will provide an automated process that provides realistic costing, tailoring, scheduling, risk management, and practical metrics.

ROADMAP



Annual Standards Category Report for FY00

VISUALIZATION

STANDARDS CATEGORY DEFINITION

The Visualization category addresses the representation of the physical environment which includes the representation of combatants (vehicles, aircraft, personnel, ships, etc.) in a dynamic environment (includes the concept of virtual and constructive entities in a live environment).

STANDARDS REQUIREMENTS

Current Army standardization requirements include:

1. Determine how Visualization relates to the other standards categories and to C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance)
2. Define and articulate attainable, adaptable, and scaleable standards
3. Implement standards

ACCOMPLISHMENTS AND ASSESSMENT

The Visualization category is essentially a new category in FY 99. Visualization has been a category previously, but focused primarily on C4I issues. A C4I category has been created to carry on this work and the Visualization category will cover visualization issues associated with the physical environment as defined above.

- Visualization team members met for the first time at the May M&S Workshop and determined the focus of the work to be addressed by this category. The category will support visualization requirements for out-the-window, sensor/radar simulations, stealth and plan view displays, battlefield visualization, after action reviews, electronic maps and data visualization.
- Relationships with other categories were developed and the visualization team determined that standards from Terrain, Dynamic Environments, C4I and Move could be utilized to meet visualization requirements.
- Determined that the focus for visualization standards will be on benchmarking, tools, and verification and validation metrics and discussed AMIP projects to address these issues.
- Developed the initial roadmap for the category.

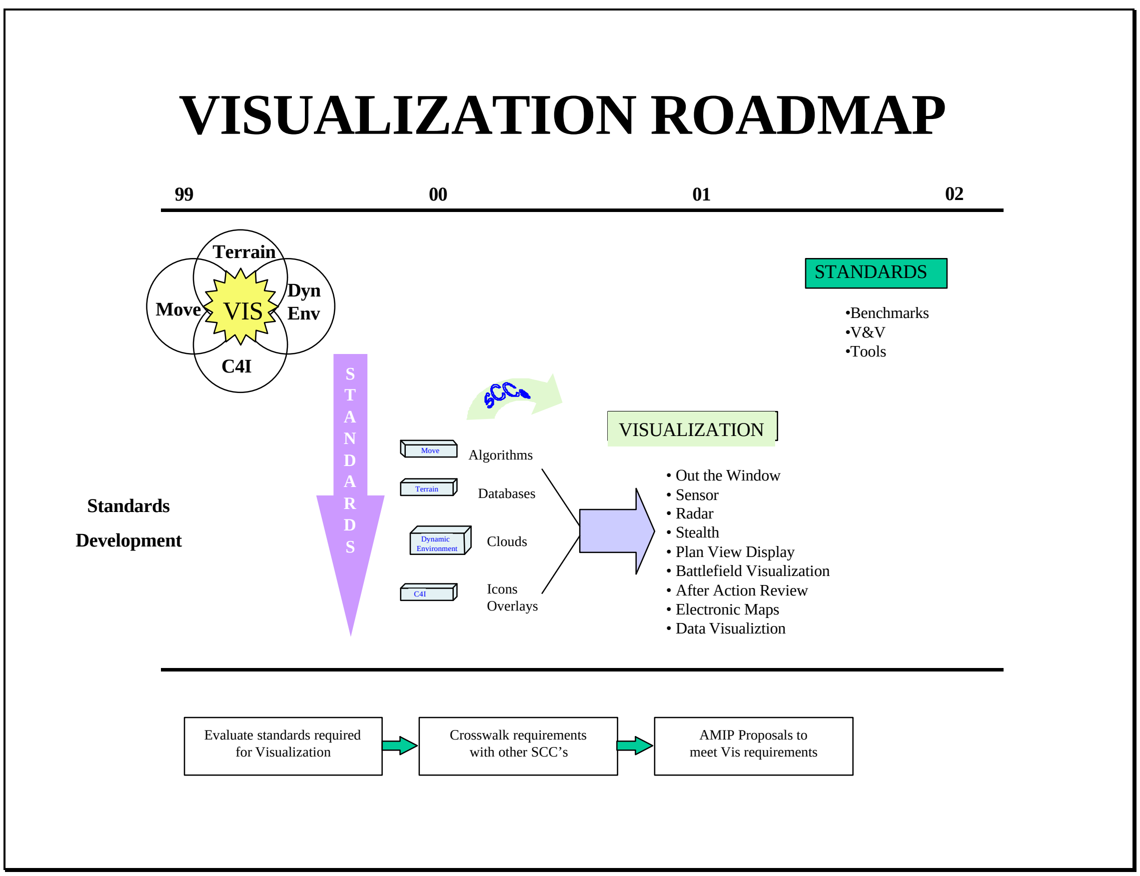
PRIORITIES FOR NEXT YEAR

The priorities for next year include documentation of interoperability issues and development of benchmarking capabilities.

AMIP Proposals Submitted:

- *Evaluation of Environmental Interoperability Issues Between M&S and C4I Systems*. The objective is to determine the best approach to sharing environmental data among C4I and M&S systems.
- *Standardizing Image Generation System (IG) Benchmarking using Synthetic Environment Data Representation & Interchange Specification (SEDRIS) Standard Testing Database (SEDRIS STDB).* The objective is to develop a standard benchmarking database for visualization using the SEDRIS data representation format.

ROADMAP



APPENDIX D

AMIP Proposals Approved to Receive FY00 Funding
(sorted by Project Title)

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PROJECT TITLE Army Object Standards Development

STANDARD CATEGORY Object Management

POINT OF CONTACT

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EXECUTIVE SUMMARY

Object Management Standard Category (OMSC) members will design, coordinate, and document objects for use as standards in Army model and simulation. Activities to be conducted are:

- Object development:
  - Mine/Minefield Objects
  - Feature Object
  - Urban Object
  - Basic Object Model
  - Behavior Framework/Object

- Coordination of draft object design with other Army Standard Categories, M&S Developers, and Database Managers
- Update of OMSC website to allow easy navigation of objects, object methods, and object definitions

FUNDING PROFILE

$K	Prior Funding & Source	FY 00 OMA	FY 00 OPA	Project Total
AMIP Funds	25	120		145
Other Source(s) of Funding*	10 (ARL)	30 (AMSAA) 10 (ARL)		30 (AMSAA) 20 (ARL)
Total	35	160		195

BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

Object-oriented programming offers the potential for increased code reuse, maintainability, and ease of developing new simulations. Because of these benefits, the use of object-oriented technologies will increase over time. To prevent duplication of effort and the development of incompatible models, the Deputy Undersecretary of the Army for Operations Research directed the development of standard Army objects for use by the M&S domains for M&S development. This proposal encompasses the tasks necessary to develop new objects as well as conduct the testing, documentation, and coordination of standard objects to insure that they contain the minimum essential elements necessary for widespread application.

TECHNICAL APPROACH

Based on the component-based OMSC design philosophy, this effort will develop functional definitions of objects that are robust and reusable by different simulation applications. This project will develop a set of objects, object methods, and object metadata proposed for M&S community use (see following list). These objects will undergo review within the OMSC and then be coordinated with other M&S organizations. These organizations will include relevant Army Standard Categories, M&S Developers, and M&S Database Managers. The draft objects, once consensus is reached, will be documented via a technical report and submitted to SNAP for approval and ASTARS for access. Additionally, objects developed by other activities will be reviewed as potential object standards (e.g., Logistic Object standards). The following will be addressed in this AMIP proposal:

- <u>Mine/Minefield Objects</u> – addresses the representation of individual mines as well as the aggregate representation of a minefield
- <u>Features Object</u> – addresses the representation of point entities (well, watertower, antenna), line entities (roads, pipelines, railroads, trench), and area entities (e.g., cities/towns, clouds, ditch)
- <u>Urban Object</u> – addresses objects within an urban area that would benefit from representation as an aggregate object vs. collection of many objects such as facilities (e.g., depot, stations, ports), massing (e.g., traffic, crowds) and buildings.
- <u>Basic Object Model</u> – this effort will explore the ability to develop and use basic object building blocks to support development of physics/engineering-type M&S.

- Behavior Framework/Object – addresses completion of the behavior object which describe behavior, from individual soldiers up to command level (e.g., command planning, order sets, perceived situation, experience, etc.)

Newly developed objects will be documented and posted on the OMSC website. Existing object entries on the OMSC website will be updated as needed.

PRODUCTS

The following reports will include a description of the object, object methods, object definitions, and example applications:

- Mine/Minefield Object Report
- Features Object Report
- Urban Object Report
- Basic Object Model Report
- Behavior Framework/Object Integration Report
- Updated website to provide documentation and references to existing object standards and draft object standards

MILESTONES

	O	N	D	J	F	M	A	M	J	J	A	S
Behavior Object												
Mine/Minefield Objects												
Features Object												
Urban Object												
Basic Object												
Update Website												

RISK/BENEFIT ANALYSIS

The projected cost for this project is $120,000. The risk to complete this effort is low-to-moderate. Initial solutions to the problems addressed by this project have been discussed within the OMSC. The major challenge is to develop a set of solutions tailored to the needs of the Army M&S community and have widespread applicability. 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, STRICOM, and ARL with consultation with TRAC-WSMR, TRAC-FLVN, TRAC-MTRY, NSC and CAA as well as other standard categories.

PROJECT TITLE BATTLE MANAGEMENT LANGUAGE LEVEL 2 (ECHELONS, BOS, COMMANDER'S INTENT, GRAPHICS)

STANDARD CATEGORY Command Decision Modeling

POINT OF CONTACT

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EXECUTIVE SUMMARY

Battle Management Language Level 2 (BML 2) will be a continuation of the success of the original BML. It will expand the breadth of the language, increase its terms and add "intelligent" graphics and Commander's Intent Language (CIL). A battle management language or BML is the military verbiage or vocabulary that military planners and operators use to provide a paper or digital order to a simulation and receive back reports in a language that the men and the machine understands. The language must work man to man, man to machine, and machine to man. Simulations which execute Command Decision Modeling (CDM) use a BML to allow "Intelligent Agents or "Handlers" to interface with the human controller in the doctrinal language which will be familiar to him or her.

In BML1 we established FM 101-5-1/MCRP 5-2A Operational Terms and Graphics as the primary source for man/simulation communication terms. Our emphasis was combat forces at all tactical levels with less attention to combat support and combat service support units. In BML-2 we will continue to emphasize joint doctrinal sources. Also we will improve the richness of the BML by identifying terms that apply to specific echelons (soldier– Corps) and to one of the seven battlefield operating systems.

The most important improvements in BML-2 will be the addition of military graphics symbols based in doctrinal sources that can be reasoned upon in object oriented programs and the initial efforts to communicate commander's intent. The military graphics symbols are a part of the Battle Management Language which represent military actions to the machines and the man and the CIL will represent the "why" of the military actions

FUNDING PROFILE

$K	Prior Funding &Source	FY00 OMA	FY00 OPA	Project Total
AMIP Funds	none	150K	110K	260K
Other Sources of Funding	none			
Total	none	150K	110K	260K

BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

Representing command and control decision-making in software is one of the critical and challenging tasks confronting the simulation community. With the development of simulations such as WARSIM 2000, JSIMS and JWARS, the Modeling and Simulations Community is shifting toward support of larger-scale, higher-fidelity exercises. These larger simulations drive an increased requirement for 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. Until the approval of BML this spring, the controllers and role players had to learn a new language in order to send orders and information to the simulation and to interpret the reports that the simulation returned to them. With BML, this man to machine, machine to man communications is accomplished in the doctrinal language familiar to all people with a military background eliminating the need to learn new languages for each simulation.

BML 1 is the foundation of this approach to standard simulation input/output, but it is not complete. BML 2 will begin the process of enriching the language by addressing terms that apply to a specific echelon or limited number of echelons. Similarly it will address terms that may be unique to one or more Battlefield Operating Systems (BOS). BML 2 will continue coordination with the Joint Common Database that is used by the C4I devices to which modern simulations must link and will explore the possibility and potential payoff of developing a BML based on foreign doctrines.

BML 2 will address two other areas that are very important to Command Decision Modeling. Military graphics provide commanders, especially at brigade level and lower, with a key tool to use in communicating orders to subordinates and to provide commanders with a rich source of information regarding their current missions. BML 2 will provide a doctrinal basis and a proven approach to representing graphics in simulations. It will also begin to address the complex task of expressing commander’s intent, the “why” of the “who, what, when, where, and why” of a standard mission statement.

TECHNICAL APPROACH

As with BML 1, this project requires research into military doctrinal publications available to us on the internet. We will establish the echelon and battlefield operating system framework and coordinate it with our doctrinal experts. Once we have consensus on the framework, we will do a term by term analysis of FM 101-5-1 and other pertinent doctrinal sources and array the terms in the framework. After coordination on the reflector and a number of other agencies this portion will be complete. The graphics package will require an analysis of FM 101-5-1 to determine which graphics require depiction and the most efficient, object-oriented method to depict the selected graphics. We will develop a prototype of a graphical system on which intelligent agents can reason and demonstrate its capabilities in our developmental system, J-MACE. Commander’s Intent Language also will require doctrinal research and coordination with Subject Matter Experts. We will then develop a syntax for encoding commander’s intent and a dictionary of important terms. Time and resources permitting, we will investigate development of an OPFOR BML using current Army doctrinal publications and Combat Training Center’s OPFOR publications.

PRODUCTS

- reference dictionaries in the form of annexes to BML 1 to cover BML by echelon and by BOS.
- a prototype simulation employing object-oriented graphics with documentation and users guides.
- a syntax and a dictionary of terms for a Commander’s Intent Language published as an annex to BML 1.
- a paper addressing the value of developing a BML for a foreign doctrine, and if appropriate a sample foreign BML annex.

MILESTONES

Milestone	1	2	3	4	5	6	7	8	9	10	11	12
Establish and coordinate Echelon, BOS and Commander's Intent frameworks	X	X	X	X								
Term Analysis and Coordination			X	X	X	X						
Graphics Analysis						X	X	X				
Graphics Coding and Coordination								X	X	X	X	
Coordination and voting BML 2											X	X
Foreign Doctrine BML possibilities	X	X	X	X								
Develop and Coordinate Foreign Doctrine BML				X	X	X	X	X	X	X	X	
Coordination and voting Foreign Doctrine BML											X	X

RISK/BENEFIT ANALYSIS

BML 2 with Graphics provides further standardization of military doctrinal language into simulation and C4I products which allows man to man, man to machine and machine to man interfaces in the same language. This allows command decision modelers to create automated forces which can react to human higher headquarters with credibility. Automated forces allow reduction of training overhead for future simulations such as WARSIM 2000. BML 2 also supports Joint Common Data Base (JCDB) improvement to support simulation links to current and proposed C4I systems which improves training realism and operational efficiency.

EXECUTABILITY

In-house contractors will conduct this work. They work under the National Simulation Center's Support Contract. Coordination (perhaps teaming) with the C4I SCC will reduce risks and benefit both categories as will our on-going coordination with the proponent for doctrinal language, the Command and General Staff College. Teaming/coordinating with the MOVE, TERRAIN, DATA, and OBJECT MANAGEMENT Categories will improve the executability of this project as well.

PROJECT TITLE Coordinate Transformation Handbook for Models, Simulations and Simulator Applications

STANDARD CATEGORY Terrain

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EXECUTIVE SUMMARY

Coordinate transformation (CT) computations can be significant users of processing time in both distributed and stand-alone simulations. By reducing this computational load more units can be simulated. For example, distributed confederations of simulations and simulators require frequent interchange of Time Space Position Information (TSPI) between computational nodes. Under DIS protocols about 20% of the total simulation time can be devoted just to coordinate conversions used to prepare TSPI for sending and receiving. Internal calculations of distance, bearing, heading and other geometric properties require additional CT computations. The increasing need to accurately represent the Synthetic Natural Environment, which depends on CT operations, will add to the problem. Improved performance provides flexibility in systems design and ultimately will have a cost benefit.

In addition to performance issues there is a need to provide accurate CT services. This need stems from a requirement to portray a level playing field, to reliably predict point membership in polygons, to accurately portray fire control systems and a host of other requirements for accuracy. Traditionally developers have sacrificed accuracy to improve throughput in models, simulations and simulators (MSS) using a variety of some times inconsistent approximations. The variability that results makes this an increasingly unacceptable practice. Standardized algorithms for CT computations are beneficial in terms of: promoting meaningful interoperability by reducing TSPI uncertainties, facilitating verification and validation, encouraging software reuse and easing simulation software maintenance. Standardized algorithms are most useful when they were both efficient and accurate. This proposal is aimed at development of a handbook for CT algorithms and code that will encourage standardized use across the Army simulation community. This handbook is envisioned as a living document that can be supplemented as new methodologies and requirements emerge. Potentially this handbook would pave the way for a joint handbook that is applicable to all DoD simulation applications.

FUNDING PROFILE

$K	Prior Funding & Source	FY00 OMA	FY 00 OPA	Project Total
AMIP Funds	0	93K	0	93K
Other Funding	DoE 90K(est.) DMSO 130K	0	0	93K
Total	220K	93K	0	93K

BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

Coordinate transformations for georeferenced systems can be developed in several equivalent mathematical forms. Some of these forms are better than others for digital computation. Theoretical formulations usually require the solution of complex non-linear algebraic equations in several variables. This involves many transcendental function evaluations, all of which are relatively expensive to compute. Three basic methods are commonly used to perform transformation computations. These include the use of: 1. power series expansions, 2. iterative methods and 3. curve fitting (including tabular approximation). For equivalent accuracy, power series methods are generally the least efficient, properly formulated and initialized iterative methods are next and curve fits of both the forward and inverse functions being almost always the most efficient.

Theoretical and authoritative efforts have traditionally emphasized accuracy and have de-emphasized efficiency. In simulation applications computational efficiency is often critical. This is true for stochastic models where many replications are required, for real time situations like distributed interactive simulations and confederations of simulations and simulators. The number of units and the number of replications are limited by computational constraints.

TECHNICAL APPROACH

As part of the SEDRIS Program, significant progress has been made in developing algorithms for CT computations that are significantly faster than traditional methods but still preserve accuracy (1 mm error ball). The main source of the computational load is due to the presence of a number of transcendental functions that appear in the transformation equations. These improvements were accomplished by mathematical reformulation to eliminate unnecessary transcendental functions, replacement of remaining transcendentals by in-line formulations and the use of multi-dimensional rational function approximations. It is proposed that these algorithms be captured and enhanced for inclusion in a stand-alone handbook specifically generated for use by simulation developers.

Proposed tasks are outlined below. For the purposes of discussion reference accuracy means equivalent to the accuracy provided by authoritative software such as GEOTRANS or NIMA DTTC4.0, high accuracy means error less than a 1 mm error ball (as in SEDRIS), medium accuracy means error less than a 5 to 10 cm error ball (negotiable). SRI developed tools used to develop rational function approximations and error optimization are not deliverables under this proposal.

TASK 1. BASELINE HANDBOOK

- Re-write the SEDRIS Coordinate Transformation Services final report for the SDK version of SEDRIS in a form suitable for simulation specific applications. Supplement explanatory material and figures along the lines used in TEC-SR-7 by abstracting information from the Draft SEDRIS Spatial Reference Model (SRM) and TEC SR 7.
- Scope limited to those transformations in the SEDRIS 2.0 product. That is interconversions between Geocentric, Geodetic,Universal Transverse Mercator, Polar Stereographic, and Lambert Conformal Conic. This set will be supplemented with Universal Polar Stereographic.
- Supply stand-alone C code including new code for UPS.

TASK 2. IMPROVED SEDRIS PROCEDURES

- The algorithms for Map Projections are readily optimizable to achieve more performance while retaining high accuracy.
- In-line trigonometric functions will be implemented for all CTs in the baseline set, while retaining high accuracy.
- Timing information for enhancements compared to previous SEDRIS algorithms.

TASK 3. TIMING AND ACCURACY COMPARISONS WITH GEOTRANS

- Perform accuracy comparisons with corresponding C code for GEOTRANS. Describe error estimation policy.
- Perform timing comparisons on Pentium processor with equivalent GEOTRANS codes. Comparisons limited to inner loop processing of large files (initialization loop ignored).

TASK 4. SELECTABLE ACCURACY

- Implement reference accuracy code.
- Implement medium accuracy code.
- Provides user options for selecting reference accuracy, high accuracy and medium accuracy procedures.
- Timing data supplied for each level of accuracy.

TASK 5. SEQUENTIAL PROCESSING

This concept recognizes that many CT computations are repetitive in MSS applications. Some data can be saved at time t(i) to be used for time t(i+1). Such processes are inherently unstable. Plan is to use a combination of Inverse Serial Parallel Integration plus a stabilizing technique and/or re-entrant table lookup with local approximations. Ideal applications are found in ModSAF, OneSAF and WARSIM.

- Sequential processing may not be applicable to SEDRIS but has high payoff for MSS.
- Error analysis related to dead reckoning policies and entity acceleration will be needed for evaluation.

PRODUCTS

Multiple deliveries are planned to get useful results in the hands of reviewers and users as early as possible. Each delivery includes an updated handbook and C code. Updated timing and accuracy information included as appropriate for each interim delivery. Initial Handbook in hard copy (10) and electronic formats (MSWORD98). Final products are the handbook that includes algorithms, error analysis, error assessment methodology and timing assessments. All relevant C code (includes code for timing).

MILESTONES

- Initial Handbook February 1 of second quarter, FY 2000
- Interim deliveries to be scheduled
- Final Report, end of third quarter of, FY 2000

RISK/BENEFIT ANALYSIS

There is almost no risk in this program due to the leveraging of existing tools, codes, published papers and extensive staff experience. To perform timing comparisons with GEOTRANS it is assumed that this code and documentation will be made available. Leverages existing government investments. Provides standards that will suffice for the foreseeable future. Reduces costs via reusability and minimization of computer resources. Increases technical options for future MSS designs.

EXCECUTABILITY

The team that developed the SEDRIS algorithms and code will conduct this research and development.

OPTIONAL TASK

TASK 6. AUTOMATED REGRESSION TESTING

Authoritative codes for CT (Coordinate Transformations) are generally not tested on a large set of points. As new algorithm developments occur it is essential that regression testing be conducted to insure that accuracy requirements are retained. In addition, timing tests must be repeated to assure that new approaches are as efficient as the previous ones. As new coordinate systems emerge, a regression baseline must be established. SRI International has developed a prototype PC based tool for the purpose of testing new algorithms that was used on the SEDRIS program. This tool is a prototype, was not designed to be of industrial strength and is not documented. In this task it is proposed to enhance the prototype to industrial strength and to enhance it to accommodate the CTs included in the program proposed to AMSO.

For most CTs very large exact reference data files can be automatically generated as gridded data and used to determine maximum errors over any applicable region.

In the case of UTM, exact files cannot be generated but the reference accuracy files generated by approved authoritative sources can be used. This is a tool intended to be used for regression testing of new CT procedures that may be proposed in the future. Both accuracy and timing test options will be provided. All of the 21 earth reference models used in SEDRIS are included. Current plan is to provide an NT compatible Graphic User Interface. The regression code is to execute on an NT/PC platform. Code will be in C and is adaptable to workstation processing (not provided). Deliverables are:

- Code in C
- Limited to SDK CTs as modified by Tasks 1 to 5.
- Provides both accuracy and timing comparisons to reference accuracy codes.
- Test files are examined to see if the points are in appropriate feasibility regions.
- Any feasible region may be tested.
- Grids can be made fine near any particular point. This promotes dense sampling near potential singular points like the poles, equator etc.
- Users manual provided.
- Error assessment policy added to Handbook.

FUNDING PROFILE

$K	Prior Funding & Source	FY00 OMA	FY 00 OPA	Project Total
AMIP Funds	0	35K	0	35K
Other Funding	DoE 10K(est.) DMSO 10K	0	0	35K
Total	20K	35K	0	35K

RISK/BENEFIT ANALYSIS

The risk in this option is low because an undocumented prototype exists. This product can be used to assess future CT computational strategies. Timing system included has more general application to other time critical procedures. Regression Tester adaptable to provide general coordinate transformation services on a PC. Leverages existing government investment.

PROJECT TITLE Evaluation of Environmental Interoperability Issues Between M&S and C4I Systems

STANDARD CATEGORY Visualization

POINT OF CONTACT

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EXECUTIVE SUMMARY

The Army has emerging requirements for M&S systems to interoperate with C4I systems. This capability will be used to facilitate training on operational C4I equipment and to provide both deliberate and hasty mission rehearsal/mission planning. In order to achieve these goals, a common environment must be provided to the M&S and C4I systems. The environment must ensure a consistent perception of the synthetic battlespace among systems networked together. Current terrain/environment databases are produced by stovepiped processes for individual simulations and C4I systems. The environmental generation processes all begin with common source products, but use different techniques to filter, integrate, value-add and format environmental data. This study will investigate the different data representations used for these two communities to determine the best approach to sharing environmental data among C4I and M&S systems. The impact of data required for either M&S or C4I systems, but not available to both processes will be evaluated.

FUNDING PROFILE

FUNDING PROFILE: $K			
Prior Funding & Source	FY 00 OMA	FY 00 OPA	Project Total
AMIP Funds	150K	$	$150K
Other Source(s) of Funding			
Total	150K	$	$150K

BACKGROUND

Evolving Army requirements for interoperability between M&S and C4I systems will require a common environment for these systems. The M&S community has dealt with the exchange of environmental data between systems in order to provide a correlated, pre-distributed environment for networked simulations. Simulations such as WARSIM and CCTT include requirements to interoperate with C4I systems, but these requirements are poorly defined.

Requirements for interoperability of terrain environments between networked simulations have led to the development of the Synthetic Environment Data Representation and Interchange Specification (SEDRIS). SEDRIS includes a data model that covers all aspects of the environment – terrain, ocean, atmosphere and space. It has become a standard within the M&S community for the representation of environmental data.

The C4I community has not yet fully defined a requirement to interoperate with simulations, but has begun to recognize that the broader range of environmental data developed for analysis and reasoning within simulations may be useful for command and control systems as requirements develop for automated decision aids. The C4I community has several systems and standards which involve the representation of environmental data. The Joint Mapping Tool Kit (JMTK) is a data exploitation system under development by NIMA and DISA to provide mapping and charting functions for C4I systems. It includes a library of software modules that allows uniform, easy access to NIMA standard data, provides common analysis functions and common display routines for 2D visualization of mapping and military data. The Digital Topographic Support System (DTSS) is a fielded Army system that 1) performs terrain analysis with a variety of NIMA and non-NIMA terrain data, and 2) has an emerging mission to produce terrain data in formats (NIMA) suitable for use in other JMTK based ABCS systems. The Joint Common Data Base (JCDB) is a common data model developed for all ATCCS systems; it includes some weather and location information.

The types of data available to C4I systems, through the supporting systems described above, must be compared to the SEDRIS data model to evaluate the possibilities for data interchange. The functions and support data required for JMTK must be projected for the future, and mapped to the SEDRIS data model.

TECHNICAL APPROACH

This study will be a joint effort between the U. S. Army Simulation, Training and Instrumentation Command (STRICOM), the National Imagery and Mapping Agency (NIMA) and the U. S. Army Topographic Engineering Center (TEC). STRICOM will provide information and data for the SEDRIS data model and NIMA will provide the corresponding information on JMTK. TEC will provide information on the DTSS.

a. Comparison of data representations: The data representations used within JMTK, DTSS, and JCDB will be evaluated and mapped to the SEDRIS data model. The primary focus will be a comparison between JMTK and SEDRIS. Analysis of the mapping data will be used to evaluate the suitability of SEDRIS to represent data required for command and control systems.

b. Projection of data required to support future JMTK functionality: The environmental data required for JMTK to support course of action analysis and other automated decision aids will be projected. The ability of simulation environmental data bases as represented by SEDRIS to support this functionality will be evaluated.

PRODUCTS

This project will provide the following products to support environmental data interchange required for interoperability between C4I and M&S systems:

- Comparison of environmental data representations used for C4I and M&S – SEDRIS / JMTK / DTSS
- Projection of environmental data required to support future automated decision aids
- Recommendations for an environmental data representation to support both simulation and command and control requirements.

Milestones:

Evaluation of C4I/M&S environmental data representations	2Q00
Projection of data required for future C4I systems	3Q00
Final report and recommendations	3Q00

RISKS/BENEFITS ANALYSIS

The technical risk associated with the proposed work is considered very low; the data for the required analysis and projections is readily available. This work will provide a good understanding of the environmental data exchange issues associated with interoperability between C4I and M&S systems, and will reduce the risk for the development of interoperable environments for future system integration. The work will provide the basis for future standards to support M&S/C4I environments.

EXECUTABILITY

This program will be executed by STRICOM, NIMA and TEC, with contractor support for approximately 90% of the effort. The contractor will be one with a clear understanding of the JMS and JMA segments of JMTK. Support may also be provided by a SEDRIS associate contractor.

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PROJECT TITLE Organizational Identity and Relationships Structure (OIRS)

STANDARD CATEGORY ODSC4

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EXECUTIVE SUMMARY

This project will develop a draft standard for organizational identity and relationships that aligns with the JCDB and supports the interoperability between M&S and C2 systems in areas not covered by the JCDB. The project will catalog the wide variety of organizational identifiers and relationships in use by major Army Battle Command Systems and current and emerging simulations. The project will address the Command, Reporting, Fire Support, and Logistical Support types of relationships. The intent is to analyze the wide variety of identifiers and relationships in use by the multiple C2 and simulation input sources to identify frequency of use, overlap, redundancy and potential mappings that can better align simulations with the JCDB and reduce the complexity of simulation to C2 system communications. In those areas where there are no standards other than system specific approaches, a proposed standard will be developed. The draft standard will be delivered to the OneSAF Testbed./Spectrum 2.0 for use in prototyping the Command and Reporting relationships.

FUNDING PROFILE

$K	Prior Funding & Source	FY 00 OMA	FY 00 OPA	Project Total
AMIP Funds	$0	$210	$12	$222
Other Source(s) of Funding*	$0	$0	$0	$0
Total	$0	$210	$12	$222

BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

"You, this is Me." Thus begins any radio communication in the Army. When only two organizations are involved, "You" and "Me" can provide satisfactory identification. However, when more than two organizations are involved, the parties involved must use some form of identify other than pronouns for clarity. That raises the basic issue: "How should an organization identify itself?" Unfortunately the answer is usually a firm "Depends!" When asked, "Who is this?," a common response is "You tell me first." This "depends" answer comes from the fact that an organization's identity varies depending upon the relationship it has with the other party with whom it is communicating.

One can assess the complexity of an organization by examining the number and variety of the relationships among its constituent parts. Military commanders define relationships among their organizations to improve the efficiency of operations. Each relationship establishes rules describing the roles and responsibilities of the parties involved. Using well-defined relationships reduces ambiguity, reduces the resources required to establish new relationships, and thereby yields the improved efficiency of operations.

However, each battlefield operating system has developed its own set of relationships and often its own set of organizational identifiers to go with them. In some cases, two or more C2 systems use different identifiers to express the same relationship. Thus establishing communications between a simulation and a C2 system often requires figuring out new ways to map the simulation's organizational identifiers and relationships with the identifiers and relationships in the C2 system. As more complex federations arise out of specialty focused federates, the mapping challenges will grow as well.

Relationships are often multi-dimensional as well. A key example is the reporting relationship. Organizational Standard Operating Procedures (SOPs) often define an Information Exchange Plan. This plan defines the reporting relationship by sender, recipient, information type, and criteria for exchanging the information. Since these plans are embedded in SOPs, there are no standards for how they are expressed. The C2 systems do not have a standard method for describing an often operator-initiated event. Thus any simulation trying to stimulate a C2 system must develop an approach for describing the information exchange plan. Again, more complex federations may have to accommodate multiple approaches. This increases the resources required to gather and initialize data among multiple federates.

Finally, as Operations Other than War, Joint operations, and Coalition operations continue to grow in importance and experience, even more complex relationships are being developed to improve the efficiency and security of our Army's participation.

TECHNICAL APPROACH

The project will focus on four major types of relationships: Command, Reporting, Fire Support, and Logistic Support. Multiple sources will be used to identify the types of identifiers and relationships used in each C2 system and simulation. Sources from C2 systems will be the data models (or database description documents) for the Army Tactical Command and Control System (ATCCS) Battlefield Functional Areas (BFAs), the Joint Common Data Base (JCDB), and the Force XXI Battle Command Brigade and Below System (FBCB2). Sources from simulations will include analysts guides, data models, or description documents from the Corps Battle Simulation, Warfighters' Simulation 2000, Janus, Spectrum 2.0, the Eagle Simulation, and the Run Time Manager.

Once the complete set of identifiers and relationships are completed, comparative analysis will be used to determine what mappings can be made to establish a smaller set of identifiers and relationships and for alignment with the JCDB.

The Command and Reporting identifiers and relationships will be provided to Spectrum 2.0/OneSAF Testbed for prototyping.

PRODUCTS

1. Catalog of major organizational identifiers and relationships used by the Army Battle Command System and legacy and emerging simulations.
2. Proposed standard for identifiers and relationships that aligns with the JCDB.
3. Prototypes by OTB/Spectrum 2.0 for command and reporting relationships

MILESTONES

Month 1	Project kick-off, D.C. Area
Month 2 – 5	Identification of sources, initial research, mapping framework established
Month 6	IPR
Month 6 – 9	First draft of oranizational identifiers catalogue
Month 9	First draft of JCDB-aligned standard
Month 10–12	OneSAF TestBed (OTB)/Spectrum prototyping
Month 12	Project peer review, publication, outbriefing

RISK/BENEFIT ANALYSIS

This project is low risk as far as developing a draft standard. The input data sources should be reasonably available. The major technical risk is in the ability of the Spectrum 2.0 program to implement the draft standard. The project attacks the standards category's objectives head on. The ability to map organizations from their simulated identification to their C2 system identification is fundamental to effective M&S and C4ISR interoperability. The four relationships that are proposed to be covered by the project cover the principal areas of interest in major stimulation events.

EXECUTABILITY

Work will be conducted using a GSA contracting vehicle already in place supporting Spectrum and RTM efforts at the National Simulation Center.

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PROJECT TITLE Turbulence Effects on Target Acquisition (TEOTA)

STANDARD CATEGORY Dynamic Atmospheric Environment

POINT OF CONTACT

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EXECUTIVE SUMMARY

Atmospheric optical turbulence effects most heavily influence visible light propagation. These effects include image blur, scintillation, and image wander. Blurring effects have been described using the atmospheric modulation transfer function (AMTF), which is influenced by turbulence level (C_n^2), turbulent inner and outer scales, path length, and wavelength. Visible band image degradation can be severe, yet current models of target acquisition do not include turbulence effects. To incorporate such effects, legacy ARL codes (MARIAH and TGRAD for surface energy calculations, LELAWS and ProTurb for turbulence effects simulations) can be compared and a single approach adopted to permit evaluation in the Acquire model of target acquisition effects and in generation of input data for running the CASTFOREM wargame model. The procedure will require modifications to the standard representations used in such models. Either the tabulation of MRC and MRTD curves for individual sensor capabilities can be extended or methods for modifying available data sets can be developed using multiplying factors. The final model will have fewer limitations and improved accuracy over current methods. The model, along with documentation, will be provided to both NVESD and TRAC. The final model will also be proposed as a standard in the standards categories areas of Dynamic Atmospheric Environments and Acquire.

FUNDING PROFILE

$K	Prior Funding & Source	FY 00 OMA	FY 00 OPA	Project Total
AMIP Funds			$95	$95
Other Sources of Funding	$560 (ARL/BE)			$560
Total				$655

BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

The near-surface atmosphere can cause blurring of images acquired at long range due to diurnal heating and cooling effects. The amount of blur is parameterized by the turbulent coherence length (r_0) which varies as $(k^2 L C_n^2)^{-3/5}$, where k is the radiation wavenumber, L is the object-observer distance, and C_n^2 is the refractive index structure parameter. Coherence length, along with the system pupil diameter, D, parameterizes the atmospheric modulation transfer function (AMTF). The incorporation of algorithms for the computation of the parameters C_n^2 and r_0 in Acquire, and their subsequent impact on CASTFOREM wargaming, is the subject of this proposal.

As turbulence (parameterized by C_n^2) increases, r_0 decreases. When $r_0 < D$ a system's ability to image distant objects becomes impaired because the received wavefront is distorted across the receiver aperture. At visible and near infrared wavelengths these distortions can generally begin to be seen at ranges as low as 100 m. Past emphasis on infrared characterization has ignored turbulence primarily because the $k^{-6/5}$ dependence results in turbulence effects of a factor of 30, smaller in the far IR than in the visible band. To characterize the effects of these distortions on target acquisition a standard target acquisition code like Acquire needs to be modified to include the AMTF.

The Army Research Laboratory (ARL) has developed several models for predicting C_n^2, r_0, and the AMTF. The statistics of these effects are well known, but they have not been incorporated into standard models like Acquire. In addition, secondary turbulence factors, such as inner and outer scale of turbulence effects and line of sight height above terrain, resulting in reduced turbulence, have never been satisfactorily introduced to any target acquisition model.

The use of the modified Acquire model must also be studied in relation to application environments like the CASTFOREM wargaming code. In this application, both modeled and measured MRC and MRTD curves may be available. These curves include both target/propagation and system/observer effects. Thus, it will be necessary to consider the use-environment when prescribing the mechanism for producing the model outputs. For example, the atmospheric conditions may form a separate output dimension in tables of multi-dimensional system-atmosphere coupled effects. Use of outputs where results must be coupled to MRTD/MRC curves generated through use of human observers may require multiplying factors or other mechanisms to account for atmospheric effects independently of pre-computed tables of system effects with no atmosphere present. The results of these considerations should be a single modeling environment for target acquisition, leading to an improved standard in the areas of Dynamic Atmospheric Environments and Acquire.

TECHNICAL APPROACH

This is an extremely feasible project. Available information on the relationship between the AMTF and optical parameters is well established, as are relationships between surface energy budget and vertical structure of turbulence. These components would need to be assembled together in the Acquire model. The new hybrid model will be developed by extracting appropriate portions of legacy models and integrating those into Acquire. Steps include adding new input parameters and subroutines to the model. It is assumed that Acquire's current routines will form the basis for modification. The final model will be provided to TRAC and NVESD along with appropriate documentation. A methodology will be considered to support turbulence modifications of MRC and MRTD results during the running of wargaming codes. The results will be represented as either multi-dimensional lookup tables or multiplying factors.

PRODUCTS

A standard in the Dynamic Atmospheric Environments and Acquire categories for determination of atmospheric MTF and tabulated results of different turbulence effects under varying atmospheric and system states, for use in CASTFOREM, Acquire, and possibly other constructive wargames or acquisition models.

MILESTONES

Q1: Initial discussions with TRAC and NVESD
Analysis of Acquire model compatibility with AMTF parameterizations.
Q2: Integration of atmospheric parameter inputs into Acquire model
Resolution of means of separability between atmospheric and system/observer effects
Q3: Integration of turbulence parameter calculations and AMTF model

Q4: Evaluation of effects tables
Improvements made
Final discussions with TRAC and NVESD
Delivery of model and documentation

RISK/BENEFIT ANALYSIS

The risk is low as models exist to support the integration. The final model supports standardization objectives for Acquire and would be submitted as a standard in *both* the Dynamic Atmospheric Environments and Acquire categories.

EXECUTABILITY

In-house: 16%
Contract: 76%
Travel: 8%

An existing cost-reimbursement no-fee (completion) contract under the Historically Black Colleges and Universities/Minority Institutions set aside with the New Mexico State University's Physical Sciences Laboratory would be used. This contract is active and supports task orders within a wide scope.

PROJECT TITLE Vehicular Mobility during Night and Vision Obscured Operations

STANDARD CATEGORY Move

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EXECUTIVE SUMMARY

The Army in recent times has been called upon to fight under the cover of darkness and/or during vision obscured operations. This requirement is expected to continue to grow in scope and demand. Current Army vehicle mobility models and the vehicle mobility algorithms in combat simulation models are severely limited in their ability to portray night and vision obscured movement operations. To eliminate this significant modeling deficiency, it is proposed that research be conducted to locate and gather available data relating to the subject matter, parameterize vehicle/driver visibility restrictions, identify data voids, construct algorithms to interpolate or extrapolate data voids, and develop a mathematical model to compute driver recognition distance as a function of illumination, obscuration, and vision enhancers (goggles).

Driver recognition distance is a parameter of the NATO Reference Mobility Model (NRMM II), an approved ASTARS standard. The developed model will be submitted as a standard for limiting the maximum potential vehicle movement speed in M&S and C4I systems via the NRMM II.

FUNDING PROFILE

$K	Prior Funding & Source	FY 00 OMA	FY00 OPA	Project Total
AMIP Funds	0	150	0	150
Other Sources of Funding	Army RDT&E FY99 150	Army RDT&E FY00 150	0	300
Total	150	300	0	450

BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

As was evidenced during wars of recent past and ongoing conflicts, the Army was and will be called upon to fight extensively at night or under vision obscured conditions. While the mobility of a vehicle in principle is independent of visibility conditions, the ability of the driver to maneuver the vehicle during low visibility conditions is significantly decreased. During such conditions it can no longer be assumed that all drivers of convoy trucks, tanks, etc., friendly or threat can see equally. In fact, the Army is counting on the threat not being able to "see" as well at night and/or through obscurants. This technological superiority of the U.S. Army is not being modeled fully or at all in the Army's combat simulation models, vehicle mobility models, and route planners. With these enhancements, combat developers will be able to realistically portray the Army's "owning the night" advantage in vehicle mobility as a force multiplier and for source selection; mission planners will more accurately determine travel time (especially off-road); and participants in training simulations will more fully realize the advantages and disadvantages of night and vision obscured movement operations.

TECHNICAL APPROACH

The approach includes gathering available data, model development, and integration.

PRODUCT DEVELOPMENT

1. Collaborate with the pertinent government agencies to establish data sources.
2. Collect and analyze data from the available sources and identify data voids.
3. Design interpolation and extrapolation methods for compensating for data deficiencies.
4. Develop mathematical model for computing driver recognition distance.
5. Integrate mathematical model into the NRMM II as a sub-model.
6. Document results.

PRODUCTS

1. Document describing mathematical model.
2. Sub-Model of NRMM II
3. AMSO Standards Submission

MILESTONES

Collect and analyze data from the available sources and compensate for deficiencies	2Q00
Develop mathematical model	3Q00
Integrate mathematical model into the NRMM II as a sub-model, document results	4Q00
Submit Standard to AMSO	4Q00

RISK/BENEFIT ANALYSIS

Already much research has been conducted and changes have been made to sensors to permit night and vision obscured operation of military vehicles. The ERDC has gained extensive experience with its field testing research of military vehicles, vehicle mobility modeling research, and its long time support to the NRMM II, M&S, and acquisition communities. The NVESD is equally experienced with research supporting night and vision obscured operations. This vehicle mobility modeling experience taken with the research to be gathered on night and vision obscured operations will result in a greatly enhanced capability for the Army to model vehicle mobility in night and vision obscured operations. The technical risk is moderate to low and this new modeling capability would touch on all areas of vehicle modeling including vehicle design, wargaming, and simulator training. The cost is low compared to the much-needed requirement for realistically portraying the Army's capability to "own the night."

EXECUTABILITY

The ERDC and the NVESD will perform at least 80% of the work in-house. The ERDC Geotechnical Laboratory will serve as lead agency.

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PROJECT TITLE Weather Impacts for JWARS (WX4JWARS)

STANDARD CATEGORY Dynamic Atmospheric Environment

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EXECUTIVE SUMMARY

The Joint Warfare System (JWARS) will be the next-generation theater warfare model. JWARS is being developed to support force structure analysis, system trade-off analysis, and warfighting course of action analysis. JWARS is in the process of including weather impacts by employing the Army Research Laboratory's (ARL) Integrated Weather Effects Decision Aid (IWEDA) rules. However a methodology for interpreting and integrating weather impact rules in such a fashion as to have minimal impact on JWARS run-time and yet provide faithful weather effects on men, materiel, and sensor systems is needed.

ARL's Battlefield Environment Division (BED) can provide such a solution. BED will accomplish this by using their extensive hands-on knowledge of IWEDA rules and physics-based weather effects models. Using the Dynamic Atmospheric Environment (DAE) category standard atmospheric propagation model XSCALE and the Acquire category standard target acquisition model *Acquire*, BED will tie probabilities of detection/recognition for given sensors and aggregate units for relating weather conditions to shortened engagement ranges. Further, an approach to assigning weather penalties based on IWEDA rules will be examined. These methods will allow JWARS to realistically account for a variety of weather impacts and lead to a DAE standard for applying weather to aggregate wargames.

FUNDING PROFILE

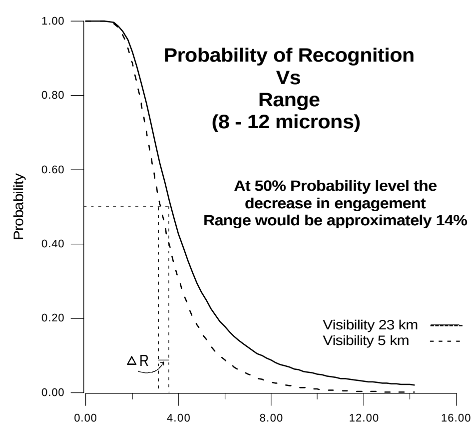
$K	Prior Funding & Source	FY 00 OMA	FY 00 OPA	Project Total
AMIP Funds			$85	$85
Other Source(s) of Funding*	$200 ARL			$200
Total				$285

BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

Most models (wargames) of air and land combat use schemes of aggregation and disaggregation in representing combat systems, in spatial configuration, and in depicting progress of a battle. In particular theater-level models are designed for planning, for budgeting and for battle analysis. This type of model is also applied in an operational context to the analysis of actual war-fighting issues such as contingency plans, estimating logistics demands, and analyzing specific combat plans. These theater-level models must also be run for the duration of the "war" and therefore are required to run faster than real-time. To accomplish all of these objectives theater-level models are necessarily aggregate or low-resolution models that combine various aspects of the wargame into units (a unit might be comprised of a number of individual entities); this aggregation is driven by the faster than real-time requirement. Effects that tend to slow down the model speed have customarily been given low priority in terms of implementation. Weather is one of these effects: *in fact no aggregate wargame currently "plays" weather*.

To rectify this JWARS is currently in the process of implementing IWEDA's rules and collecting additional service related weather rules. In the Army's case, these rules have been gathered by BED from field manuals, TRADOC centers and schools, and subject matter experts, the latter usually being experienced operators of systems. An example of one such rule would be "usage of TOW2 is not recommended for visibilities less than 3km". In conjunction with forecast weather IWEDA then presents these results for the commander's consideration in the form of stop light charts (red/amber/green) and colored map overlays. These weather impact warnings need to be tied to quantifiable system performance degradations to account for the weather effects on aggregations of entities. This must also be done in a fashion that will have a minimal effect on JWARS run time.

TECHNICAL APPROACH



For initial engagement and/or target acquisition, IWEDA's rules, which are implicitly tied to weather conditions, will be used in conjunction with the atmospheric aerosol propagation model XSCALE to determine atmospheric transmission. Coupling either an aggregate unit target contrast or temperature difference (depending on sensor type) with the transmission, probabilities of detection/recognition as a function of range will be determined using *Acquire*. The curves thus determined will be given functional fits to allow for rapid determination of changes in engagement range with respect to JWARS detection range bands in clear weather conditions (see figure). Finally other, specific weather impact rules will be assigned penalty factors for changes in probability of success, or percentage of reduced performance, or longer times to accomplish tasks, etc.

PRODUCTS

A methodology for rapid determination of weather impacts in aggregate wargames applicable to JWARS.

MILESTONES

▪ BSE determination for sensor and target mix	Q1
▪ Application of IWEDA rules for transmission under given weather	Q2
▪ Generation of probability of detection/recognition curves	Q3
▪ Provide application to JWARS for integration	Q4

RISK/BENEFIT ANALYSIS

The risk is low as all models exist and additional models are available to resolve ambiguities if necessary. The final model includes support for standardization objectives in the category of Dynamic Atmospheric Environments.

EXECUTABILITY

In-house: 30%
Contract: 65%
Travel: 5%

An existing cost-reimbursement no-fee (completion) contract under the Historically Black Colleges and Universities/Minority Institutions set aside with the New Mexico State University's Physical Sciences Laboratory would be used. This contract is active and supports task orders within a wide scope.

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APPENDIX E

SIMTECH Proposals Approved to Receive FY00 Funding
(sorted by Project Title)

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PROJECT TITLE Behavioral Continuity in Multi-fidelity, Multi-resolution Simulations (BCIMMS)

SPONSORING AGENCY TRADOC

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EXECUTIVE SUMMARY

This project proposes the study of behavioral continuity in simulation linkages involving battlefield entities. Behavioral continuity allows the ownership of simulated entities to be transferred between simulations without compromising the integrity of any executing behaviors. This project will study behavioral continuity in the context of command and control and behaviors at higher fidelities. The project will address both theory and practice of modeling and simulation and make contributions to the science of multi-resolution and multi-fidelity simulations. To ensure applicability to Army requirements, we will demonstrate the techniques in the emerging WARSIM and OneSAF simulations.

FUNDING PROFILE

$K	Prior Funding & Source	FY 99 OMA	FY 99 OPA	Project Total
SIMTECH Funds	0	250	0	250
Other Source(s) of Funding*	0	0	0	0
Total	0	250	0	250

* Be specific regarding years, organization(s) and amount(s).

BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

A *collaborative simulation linkage* (CSL) combines two or more simulations to represent the same scenario at potentially different detail levels. Conceptually, a CSL is built as shown in the example provided in Figure 9. Figure 9 shows three source simulations that are linked together to form an overall CSL. Each simulation communicates to a Simulation Interface, which then translates information into appropriate formats for the other simulations and communicates it to them; one example of this communication is ownership transfer of simulated entities from one source simulation to another. The Simulation Interface could be implemented as a single application or it could be distributed by partitioning it into components that are associated with each of the source simulations. The technique of using CSLs is one way to build multi-resolution and/or multi-fidelity simulations.

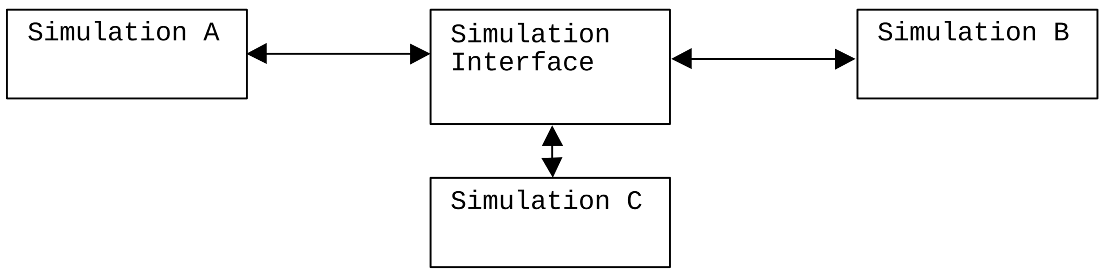

Figure 9. Conceptual design of a Collaborative Simulation Linkage involving three simulations.

A CSL allows specialized simulations to be combined at low cost to form a new simulation that provides the benefits of the source simulations while also reducing their deficiencies. As Figure 9 shows, minimal modifications are needed to the source simulations for them to interoperate in the CSL; thus CSLs do not compromise the existing investment and specialization of existing simulations. Furthermore, the CSL technique increases the flexibility of simulations by allowing them to be used more effectively for different purposes than those for which they were originally designed.

Since 1992, many prototypes of multi-resolution/multi-fidelity CSLs have been studied in the US Army simulation context. Examples include Integrated Eagle/BDS-D, Corps-Level Computer Generated Forces (CLCGF), Integrated Eagle/ModSAF/ITEMS (IEM), Janus/BDS-D, and BBS/SIMNET. In addition to providing valuable testbeds for research on multi-resolution simulation, these systems have also been used with success in US Army and Department of Defense programs. For example, CLCGF was used in the Joint Precision Strike Demonstration and IEM is being used in DARPA’s Dynamic Multi-user Information Fusion project and in Army Experiment 6. These successes show that CSLs are useful, cost-effective, and should continue to be built.

However, fundamental research challenges remain that limit the wider use of CSLs in the Army. This proposal addresses one such fundamental issue: behavioral continuity. Intuitively, *behavioral continuity* in a CSL means that the behavior of a simulated entity on one source simulation is consistent with the behavior of the same simulated entity on another source simulation. This issue arises when ownership of simulated entities is transferred dynamically during a simulation scenario from one source simulation to another. An important part of the proposed project is to formalize the notion of behavioral continuity.

Behavioral continuity is needed in both multi-fidelity and multi-resolution simulations because it provides a measure of consistency that is required for verification, validation, and accreditation. For example, when using a CSL for training, behavioral continuity is important for reasonable training results. When using a CSL for analysis, behavioral continuity is important for a sound and repeatable analysis. When using a CSL for acquisition, behavioral continuity is important for design and testing of new systems and how well the new systems fit into a scenario.

Behavioral continuity must be designed into a CSL; it is not present by default. It is an aspect of the more general issue of consistency between source simulations of a CSL.

TECHNICAL APPROACH

Because of the fundamental nature of behavioral continuity, we propose an approach that considers both the theoretical foundations of the problem and the practical application of this theory to Army models. We envision two tasks.

Task 1. Study behavioral continuity.
In this task, we would develop a more formal definition of behavioral continuity. We would develop techniques for quantitatively measuring behavioral continuity and ensuring continuity in a CSL. This task would contribute to understanding the fundamental science of CSLs and thus would be applicable to a wide range of Army models.

Task 2. Apply results of Task 1 to WARSIM and OneSAF.
The theory developed in Task 1 must be demonstrated in the context of a practical problem of interest to Army modelers. We propose to apply the theory to a CSL consisting of prototypes of WARSIM and OneSAF. There are three advantages to this approach: (1) it will show the utility of the theory in the context of real Army simulations, (2) our findings can benefit the development of WARSIM and OneSAF because these programs are still in their design stages, and (3) a useful new CSL will result from the research.

The work in this task would be performed in the context of a CSL that allows transfer of objects between prototypes of WARSIM and OneSAF. We would implement strategies developed in Task 1 for ensuring behavioral continuity in the case of command and control. We would specialize and implement the quantitative measurement of behavioral continuity developed in Task 1 in the context of command and control. We would construct an algorithm for mapping WARSIM orders to appropriate OneSAF behaviors so that the higher fidelity/resolution behavior matches the lower fidelity/resolution behaviors. For example, a OneSAF behavior for a tank entity that follows orders must generate reports to superiors in the same way that the corresponding WARSIM tank entity does.

We would then implement strategies developed in Task 1 for ensuring behavioral continuity in the case of other behaviors when an entity is transferred from WARSIM to OneSAF. We would implement the quantitative measurement of behavioral continuity developed in Task 1 in the context of these other behaviors. We would construct an algorithm to map the currently executing behavior of the WARSIM entity to a corresponding behavior in OneSAF. We would develop algorithms for transferring the behavior state, and use this state information to determine what part of the corresponding OneSAF behavior should be started. The goal will be to have a smooth transition of behavior as the entity is transferred from WARSIM to OneSAF.

IMPACT OF PROJECT ON ARMY AFTER NEXT TECHNOLOGY VOIDS

This project addresses a fundamental modeling and simulation issue that relates to all five areas of the Army After Next Technology Voids. Behavioral continuity is required for any effective cognitive modeling, logistics modeling, non-lethal weapons modeling, C4ISR modeling, and human factors performance in a CSL context. As stated in the Background section above, CSLs have already been applied in these areas with much success; we expect that CSLs will form a crucial part of the Army's modeling strategy in the future. The fundamental research proposed here will help to solidify the scientific basis for the future use of CSLs.

PRODUCTS

1. Final version of the formal definitions developed in Task 1. Interim versions will be guided by the implementation results to ensure the practical application of the theory to Army modeling needs.
2. Implementation of command and control behavioral continuity in the WARSIM/OneSAF prototype CSL.
3. Implementation of other behavioral continuity in the WARSIM/OneSAF prototype CSL.
4. Final report documenting the research results.

MILESTONES

Milestone	*Months after project begins*
Formal definitions, version 1	2
Command and control continuity	6
Formal definitions, version 2	8
Other behavior continuity	11
Formal definitions, final version	12
Final project report	12

RISK/BENEFIT ANALYSIS

There are four main benefits of this project:

1. Development of a quantitative, scientific theory of behavioral continuity in CSLs that can be applied to existing and future Army models and simulations.
2. Illustration of that theory within the context of a new CSL involving WARSIM and OneSAF.
3. Potential feedback to the designers of WARSIM and OneSAF to improve behavioral continuity for these systems. Such feedback will occur in time to have an impact on development of WARSIM and OneSAF.
4. A new CSL involving WARSIM and OneSAF that has behavioral continuity, which is a property that existing CSLs are not designed to have.

EXECUTABILITY

There is an existing contract with the Institute for Simulation and Training (IST) that will be used to execute this project.

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PROJECT TITLE C4I AAR Data Collection Module (C4I-DCM)

SPONSORING AGENCY TRADOC

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EXECUTIVE SUMMARY

The C4I Data Collection Module will provide trainers and analysts the ability to "see" into the databases on individual C4I systems and the JCDB on a near real-time basis. Working in the background, without soldier/operator knowledge or impact, specific data tables, logs and files can be mined and transmitted to a central location where they are parsed into a fusion database for cross comparison between like systems, other C4I systems, and simulation/stimulation systems. The module would be an integral component of the Common Operating Environment, used for training and instrumentation purposes, or inactive when not required. The product delivered will be a software module, which is installed on all ABCS 6.0 systems, thereby permitting extraction of training or test data for all units in the Army. This will permit full end-to-end verification of live and M&S interfaces to ABCS systems and facilitate collective training of command posts by units, BSC directors, and at the Maneuver and Capstone Combat Training Centers (NTC, JRTC, CMTC and BCTP).

FUNDING PROFILE

$K	Prior Funding & Source	FY 00 OMA	FY 00 OPA	Project Total
SIMTECH Funds	0	$250	$50	$300
Other Source(s) Of Funding*	$90			
Total	$90	$250	$50	$390

BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

Trainers and analysts of a digitized command need to answer two questions:

- What was supposed to happen?
- What did happen?

Now that the goal of electronic interoperability has been tested and adopted by the Army through the Army Battle Command System, much of the information to answer those two questions is not available in hard copy and is not archived on the ATCCS systems. The data to answer those questions are buried in databases and on files stored on the ATCCS machines. Trainers required information on a near real-time basis to permit observation of key activities in process and to facilitate quick after action review preparation. The M&S community has accepted the role to provide interfaces to ABCS for commands and echelons, which are not represented by soldiers.

The creation and modification of the C4I DCM will permit trainers, testers or other analysts to collect data from ABCS machines, without action or notice of the users of the ABCS systems. A prototype system was created for the Division Advanced Warfighter Experiment, 12/97, and has been used successfully in the Corps WFX, Prairie Warrior, MCS IOTE, CSSCS DAT, ASAS LUT, Army Experiment 5 and other events. The products provided, based on the collected information, allow exercise analysts using an AAR Server or other analysis application to compare the information collected from the C4I systems with the "ground truth" information from the battle simulation systems, currently the Corps Battle Simulation (CBS), Brigade-Battalion Simulation (BBS) and Janus. In addition, they permit comparison of locations, graphics, and enemy order of battle between C4I system workstations at different command posts or between different C4I workstations at the same command post.

Lessons learned during testing and exercises have proven that this method of data retrieval successfully accomplishes the task; however, this method is disadvantageous for various reasons. First, for every ACBS database schema change or new testing requirement, the SQL Scripts are modified, tested, and submitted to Configuration Management at the Central Technical Support Facility (CTSF). This procedure requires involvement by many parties and has occurred on a frequent basis.

Secondly, in order for the MFDC to execute scripts on an ABCS, specific system files on the ABCS must be altered to grant access to the MFDC. This requires intensive manpower to ensure access is provided at the start and throughout the duration of an exercise. Moreover, the current method of modifying system files to allow MFDC access also provides anyone else access, given the proper login name.

Lastly, with the future ABCS 5.0 release on the horizon, the current SQL Scripts and other DCARS components are not compatible and do not support dynamic routing. DCARS and the data retrieval process will require substantial modifications. This proposal provides a solution to these issues.

The prototype provides the data required, and the manpower requirements are significantly less than ever required before, however this module will allow two person operation for an entire Division or less, versus the seven required using the prototype or the 100+ required prior to the prototype.

TECHNICAL APPROACH

The scope of the implementation will cover high priority database tables, logs and graphics files. The DCARS accomplishes data retrieval by executing Structured Query Language (SQL) Scripts resident on the target C4I systems. A C4I system uses a relational database to archive situational awareness known to that system. Currently, the SQL Scripts, designed according to the database schema for each C4I system, query the C4I system database and unload the contents of the selected tables into text files. A component of DCARS, called the Multi-functional Data Collector, is responsible for remotely executing these scripts and copying the output files for processing by other DCARS components.

Figure 1 shows the DCARS control network. The system operates on three networks. The *Tactical*, or ATCCS, network permits access to the target C4I systems for capturing message traffic and for access to the information store in the workstation databases and files. This is also the network that provides access for the Analyst Workstations to browse the target C4I workstation web sites.

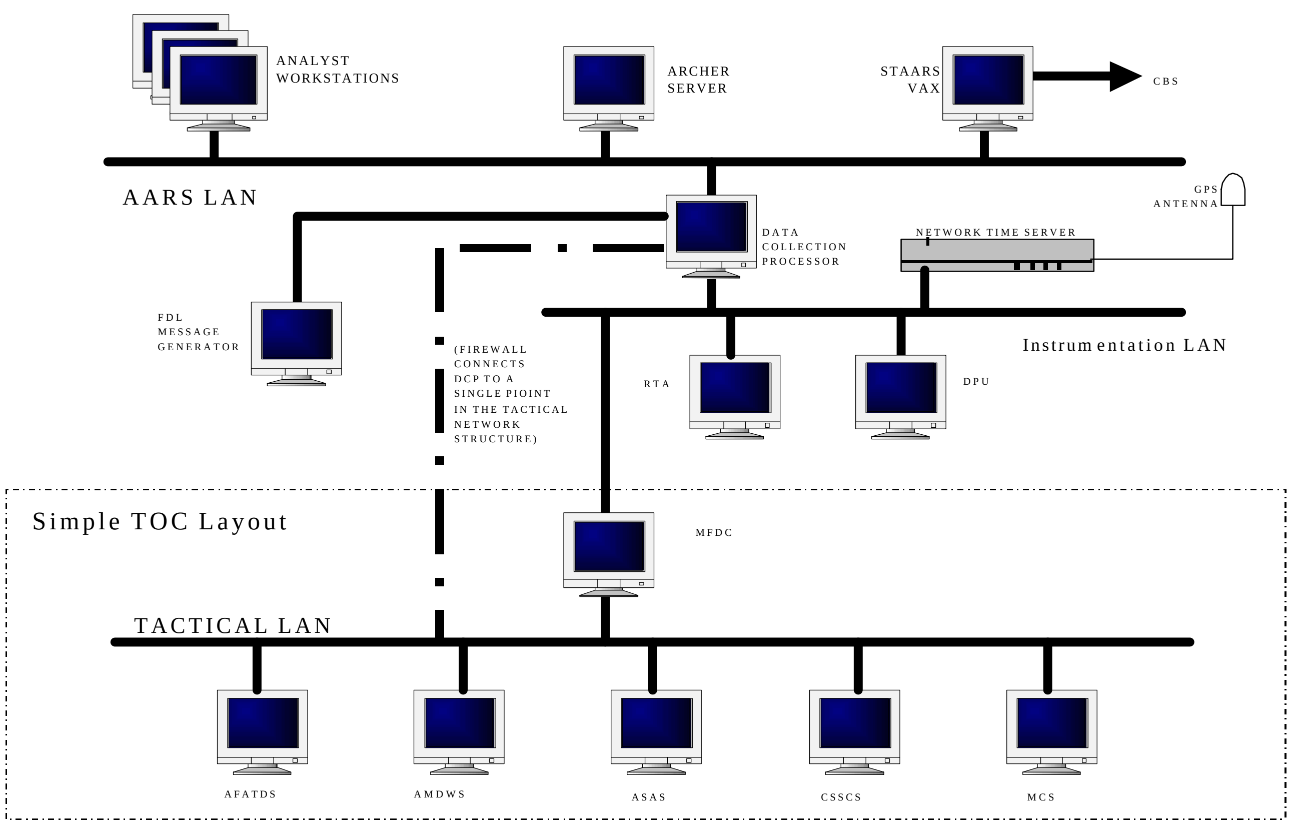

Figure 1. ABCS and Collection Network Diagram

Module Activation and Deactivation

The SQL Module, located on each system, can be activated/deactivated in three ways: menu toggle, boot process, and by a command sent by the DCP. A menu toggle will allow the C4I System Administrator to have the capability to stop DCARS collection or communications to a particular system. Enabling DCARS operation during the boot process requires additions to system level files, which should be implemented by C4I System developers. The benefit of this will allow DCARS to continue operating when a C4I system is rebooted during an exercise causing lost communications between the DCP and C4I system.

Setup Configuration

Currently, the DCARS software is a combination of UNIX scripts and text files, which are placed in a directory named EPG. The files loaded for the SQL Module will consist of these files and binary executables built from source code written in the C language. Configuration Management, at the Central Technical Support Facility, will continue to provide version control and installation management.

Module Operations

Once the DCARS Module has been initialized and configured by the DCP, the module will initialize a TCP/IP socket and begin client/server communications with the DCP. This will enable processing status messages to be sent to the DCP and allow the DCP to send setup modifications as required. In order for this to occur, each C4I System will need to reserve a designated TCP/IP socket for DCARS to use; consequently, this will require collaboration with all parties.

After a communications check between the DCP, C4I System, and MFDC, the DCARS Module will create a UNIX daemon to execute queries based on the user-defined time-interval. The output will be zipped, tarred, labeled with the system hostname and time, and sent to the designated MFDC on the Instrumentation LAN. A processing status message is then sent to the DCP.

Security

Currently, the DCARS SQL Scripts require database user privileges on each C4I System. This was accomplished by modifying system files that often requires re-modification after the system is reinitialized on reboot. To avoid the manpower required to ensure continuous operation, the proposed SQL Module will notify the DCP if permission problems exist and ensure appropriate system files provide DCARS with the necessary privileges. Little analysis of this issue has been done; consequently, this issue will need thorough inquiry and agreement with all parties.

IMPACT OF PROJECT ON ARMY AFTER NEXT TECHNOLOGY VOIDS

The second annual report on the Army After Next project establishes challenges and requirements for key technology enablers to include knowledge architectures and advanced simulations.

The requirements for the knowledge architectures include multiple route capability, semi-automated capability, configurable filters, automated decision support aids and multiple reporting formats. Each of these requirements affects the development of a robust unit IXP. While situational awareness provides overarching support for information dominance, logistical situational awareness is specifically called out in support of conducting decisive operations.

PRODUCTS

This project will provide the capability for expanded user capabilities in reading current and future digital data within the ABCS network. This allows for a decisive training and real world tool.

MILESTONES

Date	**Milestone**
Start + 3 Months	Create alpha version COE C4I DCM
Start + 5 Months	Complete Developmental Testing at CTSF
Start + 7 Months	Deliver COE Module

RISK/BENEFIT ANALYSIS

There is minimal technical risk to completing this project. The tool will support use in all three domains.

EXECUTABILITY

NSC and its materiel developer, Electronic Proving Ground, can complete all of the work.

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PROJECT TITLE C4I Jammer Analysis Model (CJAM) for Distributed Simulation

SPONSORING AGENCY ADO

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EXECUTIVE SUMMARY

State-of-the-art battlefield command, control, communications, computers, and intelligence (C4I) systems such as the Army After Next, Army Battle Command System (AAN ABCS) family of systems, including the Tactical Internet (TI), have become increasingly reliant on radio frequency (RF) based signals. Vulnerabilities of RF signals used in the TI have not been adequately evaluated in force-level exercises, training, or experimentation nor have they been adequately addressed through M&S. There is an urgent need to assess these vulnerabilities and to identify and develop counter-measure equipment, tactics, techniques and procedures. Development of CJAM will meet this urgent need by addressing AAN technology objective number 4 - C4ISR modeling.

A development team including TEXCOM, EPG and TRAC-WSMR will be lead by CECOM in a collaborative effort. At the end of FY00, CJAM will have external interfaces with other federates to support High-Level Architecture (HLA) simulation and Distributed Interactive Simulation (DIS) for interoperability with legacy models. CJAM will be hosted on a single PC-based platform and include modules to allow test, stimulation and simulation of the lower TI with jammer for GPS, SINCGARS and EPLRS frequencies. These models will be controlled dynamically during simulation through a Graphical User Interface (GUI) and will support simulation experiments with up to 2000 entities, addressing the need for simulation of Division-level exercises. Development of CJAM is low-risk and highly feasible.

FUNDING PROFILE

$K	Prior Funding & Source	FY00 OMA	FY00 OPA	Project Total
SIMTECH Funds	0	$265	$18	$283
TEXCOM/CECOM project funds	0	$225	$0	$225
Total	0	$490	$18	$508

BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

State-of-the-art battlefield command, control, communications, computers, and intelligence (C4I) systems such as the Army After Next, Army Battle Command System (AAN ABCS) family of systems, including the Tactical Internet (TI), have become increasingly reliant on radio frequency (RF) based signals. Vulnerabilities of RF signals used in the TI have not been adequately evaluated in force-level exercises, training, or experimentation nor have they been adequately addressed through M&S. Mitigating technologies to counter hostile EW efforts have not been explored within the M&S community. Widespread tactical RF jamming of C4I systems is inevitable in future conflicts in which modern (digitized) US forces may be involved.

The AAN relies on the ABCS family of systems as the foundation for its C4I infrastructure. The ABCS utilizes a “Common-Picture” and automated Command and Control (C2) to efficiently deliver the information needed to reduce the decision cycle of friendly forces to the point that friendly initiative drives the battle.

The “common-picture” and C2 Unit Task Orders (UTOs) are disseminated through the TI. The TI infrastructure at the Brigade & Below level is based upon the Force XXI Battle Command Brigade and Below (FBCB2) system – the eyes, ears, and voice of the TI. The TI and associated FBCB2 present two vulnerabilities that likely will be exploited by hostile forces. The first is situation awareness (SA). SA is the primary component of the FBCB2/AAN common-picture and is easily degraded by GPS RF jamming. The second vulnerability is the digitized communication systems (SINCGARS, EPLRS, NTDR, etc.) that are responsible for transporting digital messages throughout the TI.

There is an urgent need for these RF vulnerabilities to be assessed and for counter-measure equipment, tactics, techniques and procedures to be identified and developed. M&S provides a cost-effective means to accomplish this objective at the force level. Development of CJAM will help meet this urgent need.

TECHNICAL APPROACH

Development work will primarily be performed by CECOM with contractor support, with additional support from TEXCOM and EPG in developing and refining model design based on Simulation, Test, Operations Rehearsal Model (STORM) initiatives and from TRAC in DIS protocol coordination.

CJAM will have external interfaces with other federates to support High-Level Architecture (HLA) simulation and Distributed Interactive Simulation (DIS) for interoperability with legacy models. CJAM will include modules sufficient to allow complete test, stimulation and simulation of the lower TI with jammers covering GPS, SINCGARS and EPLRS. The GPS jammer functionality will use high-fidelity physics-based models, while jamming for SINGARS and EPLRS frequencies will use a moderate-fidelity broadband model. These jammer models can be controlled dynamically during simulation through a Graphical User Interface (GUI). Product highlights are outlined in section V. The core of CJAM development is described in the following paragraphs.

The realistic jamming effects required to experiment, analyze and study issues relating to EW threats directed at C4I systems and training stimulation necessary to support man-in-the loop training in a jammed environment will all be made possible by CJAM. CJAM will accomplish this through a Client-Server paradigm, functioning as the Jammer-Server and supporting federates through an HLA interface. These "other" federates will initially include the CECOM Tactical Internet Model Suite of simulation software (TIM Suite) and the TEXCOM STORM federation.

CJAM will rely upon the Joint Spectrum Center's widely accepted RF propagation model known as the Terrain Integrated Rough Earth Model (TIREM). Terrain information will be provided via National Imagery Mapping Agency (NIMA) Digital Terrain Elevation Data (DTED). CJAM will be coded to permit the ready incorporation of other types of terrain databases. The jammers represented in the CJAM model will be highly parameterized permitting the user to match emitters closely with known threats or to create new threats. The user can specify emitter characteristics such as antenna pattern and gain, radiated power, and modulation type. Any number of jammers can be generated, (limited by host platform), with emitters able to enter and exit a simulation with dynamic control of their signals during run-time. CJAM also will support a master-slave configuration, permitting additional PC hosts to handle the increased processing load.

To facilitate experimentation relating to systems intended to mitigate the effects of EW jamming of GPS, CJAM will interact with another related C4I model known as the CECOM Integrated GPS Navigation Model (CIGNM). The GPS AJ models included in CIGNM will employ AJ techniques such as adaptive narrowband filtering, integrated navigation (e.g.; INS aiding), adaptive nulling antennas, GPS pseudolites, and space segment augmentations. The combination of CJAM/CIGNM will accept additional AJ models.

The software architecture of CJAM will be based upon the proven software architecture utilized in CIGNM. This multi-threaded application makes full use of all available host hardware (especially useful in multi-CPU systems) to attain maximum code efficiency and throughput. Many of the jammer, antenna, terrain, and other related model components have been used and proven in CIGNM representing a reuse of software and reduction of risk in the development of CJAM. Advance coordination has already been completed to determine an appropriate approach for CJAM to provide relevant data to the Communication Effects Server (CES) model that is part of CECOM's TIM Suite and part of the STORM federation.

CECOM is also conducting work through a SBIR contract to develop a C4I Reference FOM that is intended to be submitted through the Simulation Interoperability Standards Organization (SISO) to become an Army/International standard Reference FOM. The CECOM SBIR manager is also the C4IST Forum Chairman of SISO. This ongoing effort will be heavily leveraged in the development of the CJAM HLA interface, reducing risk and including CJAM object attributes and interactions in this emerging standard FOM.

IMPACT OF PROJECT ON AAN TECHNOLOGY VOIDS

CJAM will provide the opportunity to study the effect of Tactical C4I EW (Jamming) on the AAN at the entity-based force-level, bridging the gap between ECM analysis done at the single-entity level and the objective of discerning the EW impact on overall AAN force-strength.

When joined with other federates such as the TIM Suite or STORM, CJAM will provide a means to perform detailed studies of the overall mission effectiveness of a force exposed to RF jamming against both GPS receivers and SINCGARS and EPLRS radios in constructive, virtual and live simulations. The mitigating effects of a wide variety of selectable GPS ECCM (anti-jam) technologies will also be observable. In virtual and live experimentation (as well as training), CJAM adds the realism of RF jamming to man-in-the-loop exercises.

PRODUCTS

1. CJAM model including the following basic components & characteristics:
    a. Windows NT-based server system code & hardware.
    b. Selectable interface modes: DIS and HLA (proposed SISO standard).
    c. Graphical User Interface
    d. High-fidelity GPS static jammer module.
    e. Broadband static jammer modules for SINCGARS and EPLRS.
    f. Single PC platform capable of supporting Division-level experiments/scenarios of up to 2000 entities.

    g. Standard RF propagation models (TIREM) with DTED-based terrain.
    h. Data logging and non real-time analysis tool.
    i. CIGNM interface for modeling of GPS Anti-Jamming techniques.

2. Documentation that includes the following major elements:
    a. Hardware requirements and installation procedures.
    b. Complete, detailed operation instructions.
    c. Limited description of concept of model functionality.

3. C4I Reference FOM (SISO standard) including objects and interactions of CJAM and related federates.

4. Basic test data verifying model functionality & accuracy.

MILESTONES

Month 1:	Core software and draft interface designs.
Month 5:	HLA/DIS selectable interface ready for testing.
Month 6:	Static GPS jammer model.
Month 9:	Static SINCGARS and EPLRS broadband jammer.
Month 10:	Draft documentation containing installation guide, operating procedures and concept of functionality.
Month 11:	CJAM ready for 2000 entity stress testing. Test data used for model verification.
Month 12:	Final CJAM v1.0 software, documentation and test data.

RISK/BENEFIT ANALYSIS

Previous development experience with CIGNM, the experience of the entire development team through modeling of the TI both with the TIM Suite and the STORM Federation, and leveraging of ongoing FOM development through the CECOM SBIR all strongly suggest a low-risk, highly feasible approach.

Benefits realized may be significant and likely will be found in several areas. The enhancement of a C4I Reference FOM to include the attributes of CJAM will possibly have wide-scale impact through international adoption. CJAM itself could make an immediate impact on FBCB2 testing in support of its MS III decision, influencing ongoing development of the TI. Lessons learned through CJAM development will also have immediate application to the development of many other distributed simulation models by several agencies, including CECOM, EPG, TRAC-WSMR and the Joint Spectrum Center (JSC), especially in the area of HLA code development. CJAM may also be used in the near future to support other experiments such as GPS-JOBE, CERDEC's System of Systems Interoperability (SoSI) initiative and many other efforts related to digitization of the battlefield in preparation for AAN.

EXECUTABILITY

A team consisting of CECOM, TEXCOM, EPG and TRAC-WSMR will collaborate on the development effort. Primary contributions from TRAC will include consultation on DIS protocol for interoperability with legacy systems. TEXCOM and EPG will provide guidance and consultation in the design and development based on characteristics and capabilities of the STORM program. CECOM will lead the effort and integrate design, code development, test and C4I FOM development. Travel expenses and labor for consultation will be paid from OPTEC and CECOM funds. Roughly 70% of SIMTECH funds will be applied to contract for final code development. Contract DAAB07-96-D-H002 is a 5-year C3 TE&I Support Contract with Computer Sciences Corporation (CSC); year 4 (option) beginning in April 2000. The remaining SIMTECH OMA funds will be applied to CECOM engineering salaries. SIMTECH OPA funds will be used to purchase the CJAM server platform.

PROJECT TITLE Multi-tier Simulation of Executable Architecture Views (MSEAV)

SPONSORING AGENCY DISC4

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EXECUTIVE SUMMARY

The current approach to the design of command and control (C2) systems relies on the proper linkage of the operational architecture (OA), system architecture (SA), and technical architecture (TA). At present, current means of defining the OA purport to capture the interchange of command functions and information flows. From this, the system designer should, in theory, be able to construct a viable system architecture that satisfies the information processing requirements of a commander and staff at the unit level depicted in the OA. In reality the OA does not allow for a quantitative analysis of what needs to be created or engineered. Hence, the current effort to digitize the Army faces additional challenges due to an inability to adequately account for the actual process and information requirements necessary to perform C2 in a digitized environment. An associated problem is the difficulty in configuring a digitized command post and linking it to a simulation to ensure appropriate interaction among the staff cells during an exercise, experiment, test, or mission rehearsal.

This proposal will address these problems by developing a practical method of defining the relationships and interaction of the OA and SA in a way that supports the assessment of the resulting integrated architecture in terms of measures of performance and effectiveness in an operational context.

FUNDING PROFILE

$K	Prior Funding & Source	FY 00 OMA	FY 00 OPA	Project Total
SIMTECH Funds	$0	$150K	$88	$238K
Other Source(s) of Funding	MITRE $327K, FY 99	MITRE $327K	$0	$654K
Total	$327K	$477K	$88	$892K

Multi-tier Simulation of Executable Architecture Views (MSEAV)

BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

The problem of how to develop architectures in a way that provides real support to the effective design, acquisition, and application of C4ISR systems has received major emphasis over the past several years, both within the Joint arena and across the Services. A key development in this process has been the adoption of the Joint Technical Architecture (JTA) as a means of standardizing the terminology and representation methods that are used to describe architectures. One of the main tenets of the JTA is the recognition that multiple architectural views are necessary to properly represent a system. These views display the structure and behavior of the system itself, the way the system is used in an operational context, and the technical construction of the system. Hence, they are separated into System Architecture (SA), Operational Architecture (OA), and Technical Architecture (TA) views. These are not considered to be independent views, but rather interrelated structures. The utility of a fielded system depends to a large extent on the appropriateness of the System Architecture in serving the intended Operational Architecture and its degree of conformance to the specified Technical Architecture.

Current architectural descriptions lack the capability to address issues that cross boundaries between these architectural views. Specifically, there is no systematic way to:

> (1) Examine alternative command post layouts with appropriate C4ISR systems linked to a simulation to assess the effectiveness of the CP design in meeting warfighting requirements during training, exercises, experiments, testing and mission rehearsals.
> (2) Assess the degree to which C4ISR system architectures support the operational architecture.
> (3) Estimate the performance characteristics of a system architecture in an operational context.

The challenge inherent in this view structure is to provide a means of specifying architecture relationships so that the consequences of these interrelationships can be explored. This challenge holds three problems:

> (1) Specification problem: How to specify the architectures so that correspondences between the various architectural components can be identified, mapped and investigated.
> (2) Organization problem: How to array personnel and staff organizations to effectively utilize the design architecture in the accomplishment of military functions.
> (3) Evaluation problem: How to determine the utility of a given architectural solution or design in terms of measures of performance and effectiveness, related to the military function it enables.

TECHNICAL APPROACH

Considerable effort has been expended in recent years both to develop methodological approaches that support the JTA and to develop architectural products specific to certain aspects of military operations, such as Army C2 Operations Planning, or to individual exercises, such as the Division Advanced Warfighter Experiment (DAWE). The intent of this effort is to make maximum use of the existing investment in architectural products and COTS tools, in this case, in the Army's IDEF0 modeling. With this as a given, the unique contribution of this effort is in its approach to solving the three key technical challenges described previously: the specification, organization, and evaluation problem. By doing so, a tool can be developed that will allow a commander to review his command post layout and dynamically assess its operational effectiveness in meeting his mission needs. Once the commander is satisfied with the layout, the tool can generate technical overlays for the organizations responsible for physically configuring the command post.

It is important to recognize that component views of an architecture must be specified formally and rigorously if one is to have any hope of identifying and correlating elements across the architectural boundaries of the common data environment. One way of ensuring an adequate level of specification rigor is to require that the architectural specification represent an executable model of the architecture, either *in toto* or in part. Since a simulation is simply an interpretive machine, and as machines are notoriously unforgiving when it comes to inadequately specified inputs, ambiguities and inconsistencies in the specification will become readily apparent when the specification is executed as a simulation. If the executing model is correct, that is, if the behavior of the model corresponds to the behavior that the architecture was intended to convey, this executable specification then becomes an ideal resource for the integration and correlation of other architectural components.

The guiding principle of this approach is that architectural specifications must be executable in a model. Given executable specifications for components of the architecture, the solution to the specification problem consists of the successful integration of these components into a single, distributed simulation. The technical approach will:

- Import existing IDEF0 records into an entity model called Live Analyst, to represent activities, information flows, organizational structure, and resources;

- Link the representation of Live Analyst to Design/Colored Petri Nets (CPN) to represent the system architecture as a functional model;

- Link the CPN model to OPNET to represent network layers inherent in complex C4ISR solutions;

- Integrate the architectural specification as a distributed simulation using Java-based Broker/Scheduler that implements HLA standards;

- Use ObjecTime to develop a representation of the ABCS software architecture and integrate this model into the simulation federation.

IMPACT OF PROJECT ON ARMY AFTER NEXT TECHNOLOGY VOIDS

This project offers an opportunity to refine and perhaps reengineer the process for developing and using C4ISR Architecture View products. As the Army begins to develop the C4ISR systems that will support the Army After Next, it will need a developmental process that is more responsive and informative to the acquisition process than what currently exists. This project has the potential to identify better modeling and simulation techniques for developing and linking the Operational and System Architectures so that they truly provide an accurate and complete representation of the complex command and control process using C4ISR systems.

Successful resolution of the technical challenges implicit in this project will be of great value in steering architecture development efforts toward more rigorous methodologies that support dynamic assessments of C4ISR architectures through modeling and simulation. This approach may well apply to existing systems, but there is also the potential for substantial payoff in verifying the performance of architectural solutions early in the acquisition cycle. In particular, a functioning model would be a very useful resource in support of formal definition of system requirements, resulting in reduced acquisition costs while improving the understanding of system requirements. This work could conceivably provide the DoD with a follow-on specification for accomplishing architecture design, replacing the current modeling techniques, in particular IDEF0. Finally, the tools developed here could assist a commander and his staff in rapidly developing and implementing a command post design to meet specific mission requirements.

PRODUCTS

SURVEY REPORT

The Contractor shall provide a Survey Report that describes the current state of the art and the technology available to support the development of a Command Post Configuration Tool. The report should be provided to the project officer for review 30 days before the final acceptance milestone.

REPORTS/REVIEWS

The Contractor shall provide quarterly status reports to the Project Officer. The final report will contain a technical description of the research effort, results and recommendations. The report will be written at a level that is acceptable for presentation at the Fall 2000 Simulation Interoperability Workshop (SIW).

DEMONSTRATION

The Contractor shall demonstrate the executable architecture to show the dynamic linkage of the OA and SA using a representative slice of the Army's organizational structure that captures a reasonable cross section of operational functions.

MILESTONES

The Contractor will provide cost data and a projected milestone schedule for completion of these tasks as documented, including a schedule for the delivery of the products described above.

RISK/BENEFIT ANALYSIS

There is every reason to believe this project will be highly successful. Substantial progress has already been made on key elements of this project as an outgrowth of internal Contractor-funded activities. This progress has already developed some of the techniques required to successfully carry out this project. This effort has an excellent opportunity to develop new standards for architecture products as well as improve the process for developing and using these products.

EXECUTABILITY

This project will be executed entirely by MITRE. There is internal MITRE funding and work allocated for part of this project contingent upon the research being approved for continuation into FY00. This will include a license for each of the primary COTS software (Live Analyst, Design/CPN, ObjecTime, and OPNET).

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PROJECT TITLE Semi-Autonomous Planning, Preparation, and Execution Review (SAPPER)

SPONSORING AGENCY AWC

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EXECUTIVE SUMMARY

Future battle command decision support systems will require the use of large-scale knowledge-based technologies to provide automated real-time feedback and faster than real-time predictive capabilities to aid decision-making. SAPPER will address this requirement by integrating the capabilities of CADET, a CECOM SBIR prototype Course of Action (COA) analysis tool, HITEK, DARPA's High Performance Knowledge Bases COA critiquing prototype, and National Simulation Center's Military Art of Command Environment (MACE). The result will be a prototype knowledge-based decision support system that allows rapid development, analysis and wargaming of COAs for brigade and division level operations. The SAPPER project constitutes a first step towards operational transition of this important capability into the Army's applied development programs. The project will provide a vehicle for requirements analysis targeting application of simulations in advanced decision support and planning tools. The principal objectives are enabling commanders and staffs to rapidly generate, analyze, and wargame multiple COAs using a prototype automated battle planning decision support system, evaluating potential decision support system architectures, and providing a knowledge-based framework for rapid prototyping, and follow-on integration of other, maturing technologies.

FUNDING PROFILE

$K	Prior Funding	FY 00 OMA	FY 00 OPA	Project Total
SIMTECH $ AWC/NSC&BCBL	none	100K/100K	110K / 0K	210K / 100K
Other Sources	none	none	none	
Total	none	200K	110K	310K

BACKGROUND AND TECHNICAL DESCRIPTION OF THE PROBLEM

Currently, the Military Decision-Making Process (MDMP) is Planning-focused. Data is collected and processed periodically by the staff. To prevent information overload, this data is pre-processed prior to sending it to higher/lower, echelons based on Commanders Critical Information Requirements (CCIR), reporting requirements, and time. The staff takes this data and attempts to transform it into a clear, concise picture of the current battlefield. This process builds inherent latency into the data. The process is labor intensive and time consuming. Often the commander and staff are limited in the detail and scope of their analysis by the time available to synthesize information and develop, compare and contrast alternative courses of action.

While the current MDMP results in some parallel planning, it is mostly sequential in nature. Each commander visualizes his or her own picture as a basis for decision. Once a Course of Action (COA) is decided, the commander's intent and the plan are sequentially passed to the next lower echelon for them to repeat the sequence.

Future battle command will require information technology that provides battlefield commanders with the ability to manage, synthesize and employ the enormous volumes of data and information available through advanced communications and sensor technologies. Simulation technology is a critical component of future command and control decision support systems. Increased operational tempo combined with the speed, flexibility and lethality of advanced technology equipped forces will demand commander- centric enhanced planning and execution monitoring capabilities. Simulations will provide integral support for rapid analysis and comparison of competing courses of action. Simulations will provide the commander a collaborative virtual environment for rehearsing and refining proposed plans. The result is the ability to fight emerging conditions (enemy actions) and adapt quicker to a dynamic battlefield environment. Planning and decision support systems with integrated simulation technology will lead to increased situational awareness enabling a commander to initiate adaptive planning and execution.

TECHNICAL APPROACH

The SAPPER program will develop, demonstrate and evaluate application of MACE simulation technology to an integrated course of action critiquer and elaboration system. The result will be an integrated prototype system to help military planners rapidly generate, critique and wargame courses of action. The effort will leverage NSC's MACE technology, knowledge base technology under development by DARPA's High Performance Knowledge Bases (HPKB) program and the Course of Action Display and Evaluation Tool (CADET) being developed under CECOM sponsorship by Logica Carnegie Group**.** MACE is being developed by NSC to meet Army requirements for a stable, flexible and user friendly tool to rapidly develop courses of action and to rehearse them in a time constrained, highly stressful, widely distributed environment. The HPKB program is developing new technologies to rapidly construct and exploit large reusable knowledge bases to address operational needs. HPKB has developed a prototype system for critiquing COAs called the HITEK (High-performance Integration, Transformation, and Exploitation of Knowledge) critiquer. This product assists planners in determining whether or not a COA is viable, assessing the strengths and weaknesses of COAs, and suggesting ways to improve a flawed COA. CADET is a battle-planning tool being developed under the sponsorship of Army CECOM. CADET assists military planners in translating an initial maneuver course of action (COA) into a detailed COA. The SAPPER program will build on these efforts to provide a unique and powerful decision support system for assisting military planners.

IMPACT OF PROJECT ON ARMY AFTER NEXT TECHNOLOGY VOIDS

A novel prototype battle command decision support system will be developed through the integration of several on-going technology efforts to support future battle command initiatives. Integration of these technology efforts will provide an initial end-to-end automated capability for generating and analyzing multiple courses of action in detail, in less time, and with reduced level of effort. The SAPPER program also offers a potentially revolutionary capability for conducting commander and battle staff training, by facilitating rapid generation of planning products, and by providing real time feedback and recommendations on feasibility, acceptability, and suitability. The proposed system will enable the user to rapidly change initial conditions to generate an action/reaction response cycle with which to develop and evaluate commander and staff proficiency.

PRODUCTS

- Prototype Battle Command decision support system-of-systems
- Prototype Commander and Staff training materials using SAPPER as the training driver

MILESTONES

Milestones	1	2	3	4	5	6	7	8	9	10	11	12
Technology Assessment of Components	**X**	**X**	**X**									
Establish and Coordinate Target Capabilities of Sapper Components			**X**	**X**								
Integration of Components				**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Experimentation							**X**	**X**	**X**	**X**	**X**	**X**
Development of Training Prototype									**X**	**X**	**X**	**X**
Project Complete												**X**

RISK/BENEFITS

Risk. This is a low risk/high payoff program. The program leverages the significant investment in technology components of future battle command system of systems. The NSC's use of a flexible simulation environment to build its MACE product minimizes the risks inherent in linking CADET, HITEK, and MACE. One of the strengths of the MACE environment (G2) is its ability to bridge with other dissimilar products.

Benefits. The benefits to the Army, both in the near- and long-term, are significant. Course of Action development, analysis, and selection are the most critical and often the most time-consuming aspects of the Military Decision-Making Process. Coordinating and rehearsing the results of the process with subordinate and higher headquarters are often slighted for lack of time or distance considerations. SAPPER will address all of these shortcomings. The system has the potential to greatly decrease the time the commander and staff must spend on developing, analyzing and selecting high-quality courses of action, and it's MACE component will support long-distance, real-time coordination and rehearsal of COAs. SAPPER also will provide unique training capabilities to commanders and staffs by allowing them to practice decision-making skills using systems present in their command posts and to receive immediate feedback. Finally, the SAPPER components will demonstrate the effectiveness of AMSO standards by implementing BML in MACE and HITEK (already implemented) and by examining the possibility of incorporating standards from other categories such as Terrain, Object Management, Environment, and Move.

EXECUTABILITY

As a system of systems, SAPPER has three organizations developing its components. The NSC is developing MACE using in-house resources, contractor resources, and assistance from JPL; appropriate support contracts are in place. CECOM and DARPA have contractual vehicles in place for CADET and HITEK, respectively.