Proceedings of the 1993 Winter Simulation Conference
G.W. Evans, M. Mollaghasemi, E.C. Russell, W.E. Biles (eds.)

THE JOINT MODELING AND SIMULATION SYSTEM A COMMON MODELING ARCHITECTURE FOR THE DOD

Lt Col David B. Russell

ASC/RWXM Bldg 28
2145 Monahan Way
Wright Patterson AFB
Ohio 45433-7017, U.S.A.

William K. McQuay

WL/AAWA-1 Bldg 620
2241 Avionics Circle Ste 16
Wright Patterson AFB
Ohio 45433-7318, U.S.A.

ABSTRACT

The Joint Modeling and Simulation System (J-MASS) is developing an architecture which will enhance the modeling and simulation (M&S) capability of the Department of Defense (DoD) community. The development standards and software tools implemented by J-MASS supports a disciplined approach to the development, configuration, operation, and analysis of digital models and simulations. J-MASS is an object-based modeling system designed to enhance supportability and maintainability. J-MASS will provide a library of verified and validated software components and models of weapon systems developed by the RDT&E community, models of threat systems developed by the intelligence community, and models of environmental effects provided by the scientific community. Because the models developed under J-MASS will have software components that are designed to consistent standards, the components can be reused to rapidly build other models and simulations. This ability to readily access and reuse existing models and components will result in large savings to the DoD in an era of shrinking budgets. J-MASS will truly provide the DoD with a common modeling architecture.

1 INTRODUCTION

As the budget shrinks, it should not surprise anyone that M&S will take a bigger role within the Department of Defense (DoD). In the past, models and simulations were designed for specific, narrowly defined purposes rather than for general application in the DoD community. This meant models and simulations designed for one organization usually did not work for another organization. When a new model was needed or an old required updating, it had to be designed from "square one" because there was no method to leverage off earlier efforts. The result is a large collection of models and simulations that are fragmented, uncoordinated, and lack interoperability. The DoD is taking steps to remedy the situation.

1.1 A New Way of Doing Business

At Wright Patterson AFB OH, the Joint Modeling and Simulation System (J-MASS) Program is developing a new way to effectively support M&S. The program is managing the development of a standard modeling architecture and simulation system to support tri-Service requirements. A detailed System Specification, documenting the extensive requirements generated by the tri-Service working groups, has been completed. A prototype architecture has been developed, delivered, and demonstrated with a threat radar model designed and built according to the standard. When complete, the J-MASS architecture will provide the DoD with the structure and software necessary to reduce M&S development and operational costs, increase performance and credibility of models, enhance responsiveness to user requirements, and decrease the proliferation of duplicative models.

2 WHAT IS J-MASS?

J-MASS is a ***modeling system*** that can be used by engineers, testers, model developers, analysts, and decision makers. J-MASS implements a series of standards and provides software tools

to support the development, configuration, operation, and analysis of models and simulations at varying levels of complexity and fidelity. J-MASS also provides a library of ***verified*** and ***validated*** models and software components for the model designer to use. Formal Configuration Management ensures the library retains its integrity. It is important to remember that J-MASS is ***not a model***; it is a system to develop and support models developed in conformance to the basic J-MASS architectural standards.

J-MASS supports models with an object based design and an ***open systems approach***. It is designed to be ***transportable*** between different hardware configurations and is built to operate with any work station using a POSIX compliant UNIX operating system. Standards are specified wherever possible enabling J-MASS software to interface with other standard software. To keep the cost of J-MASS ownership down, a very limited amount of commercial off-the-shelf software is being included only where there is a demonstrated benefit as compared with government owned or government developed software.

One of the key parts of the J-MASS design is the Software Structural Model (SSM). Based on work from the Software Engineering Institute and ARPA, the Software Structural Model defines a ***template*** for each object. It identifies standard interfaces in the Simulation Support Environment (SSE) and uses information with standard formats. It does not force a modeler to do more work; it simply tells the modeler where to place different attributes of the individual objects, thereby ensuring standardization.

From the perspective of the SSE, all objects are processed in the same manner. Information is provided to the object when its state is updated and the object provides information back to the SSE. The designer can focus attention on designing the algorithms needed to describe what is being modeled rather than on the style of the model. The J-MASS Code Generator transforms the algorithms into actual code compliant with the J-MASS Software Structural Model.

Using the J-MASS, model developers will be able to leverage off earlier efforts. The ability to readily access existing models and interchange parts can go a long way towards solving current M&S needs. Because models developed under J-MASS have software components that are designed to consistent standards, they can be reused in many new model designs. This approach encourages model developers to focus resources on "new inventions" rather than simply "reinventing the wheel". J-MASS also supports traditional software verification and validation by giving greater insight into the design of the software while helping ensure proper documentation. J-MASS defines the style for developers to use, but it ***doesn't limit their creativity***.

Physically J-MASS includes the Simulation Support Environment and the Modeling Library. The Simulation Support Environment provides the functional support to advanced model developers as well as to model users at lower levels of technical sophistication. The Modeling Library provides the home for the reusable model components, whole models, stored scenarios, environmental representations, geography, and other parts of the system.

The Simulation Support Environment supports the modeler in accomplishing any or all of these five basic functions:

Develop Model Components
Assemble Model Components
Configure Scenarios
Execute Scenarios
Post Process data

2.1 Develop Model Components

J-MASS models are ***based on real-world objects or phenomena***. The first step a user will take is to partition the system into its components. Wherever possible, a one-to-one mapping from the physical world to the simulation is maintained. This process continues to the level the modeler needs to provide the detail appropriate to the task. For example, a design engineer may partition a radar system into individual gates and amplifiers in the circuitry while a systems analyst may decompose the same radar into only a transmitter, processor, and receiver. The Simulation Support Environment allows ***model development to***

match the needs of the modeler without forcing detail beyond that required.

2.2 Assemble Model Components

Once a user partitions the system into its components, a library of already developed objects can be accessed. Say test engineers need a model of a gate, they simply access the library, browse through listings and descriptions of the gates, and retrieve the one that matches the need. The specific attributes for that object are "tailored" for the specific application. The engineers have now used an object developed and validated by another modeler. They have saved time and money and are assured of a quality product because all of the objects in the library have been thoroughly evaluated. This process is continued for all the parts of the system being developed. Usually, in a given simulation many objects are used over and over in varying configurations but with unique data -- ***attributes*** -- to produce very complex models. The model parts are easily connected since the models are all based on the J-MASS Software Structural Model.

2.3 Configure Scenarios

Once a model is developed, it can be placed in a simulation scenario. The scenario may be a "one-on-one" simulation where the action of a particular component in a system is evaluated or, it may be a "few-on-few" simulation where the focus is on system interaction. J-MASS allows the models in the simulation to be placed in specific physical locations using geographic models based on data from the Defense Mapping Agency. Additional atmosphere, surface cover, and other factors can be easily added to the scenario. For mobile models like aircraft, the modeler plans the route and the initial positions. These scenarios may be stored and retrieved as needed. They can also be changed at will to meet a nearly infinite number of "what if" drills. J-MASS is also being developed to support simulations involving "many-on-many" player interactions. These scenarios, most likely involving analytic J-MASS models, will support complex test scenarios as well as training and war gaming requirements.

2.4 Execute Scenarios

During setup, the operator specifies the data required for subsequent analysis. At execution, the scenario is played out and the data is captured in files for later analysis. For the real time application, data will be available for instant viewing. Modelers can execute complex scenarios using several different models knowing that individual models will interact properly because each is designed and built to the same standards!

2.5 Post Processing

In the Post Processing phase, J-MASS supports an extensive analysis capability. Users will be able to generate engineering graphs, tables, maps, traces of actual vs predicted value, position, and almost any imaginable representation of the data. For those users requiring less detailed information, the system has a visual playback capability to allow review of a test flight or an engagement. This review can be from any number of viewpoints.

3 TODAY'S CAPABILITIES

Today, J-MASS has completed prototype development and signed an Engineering Manufacturing Development contract. The first and second formal software releases of the architecture, Release 1.0 and Release 2.0, were delivered in March and September 1993. Subsequent releases of the architecture software are scheduled approximately every six months. Additionally, other organizations have developed models of several different military systems in conformance with the J-MASS standards.

While today's capability of J-MASS is limited when compared to the total system specification, Release 2.0 provides an initial capability. Functionality throughout the SSE allows the user to log on to J-MASS and develop components, assemble them into models, configure a simulation scenario, execute the simulation, and analyze the results through post processing. While a user is performing these functions, on-line tools are available to help the user generate code and data.

In the real time arena, J-MASS is exploring changes which may be required to the software structural standard to support real time

hardware-in-the-loop, installed system test facility, and operator-in-the-loop applications. Work is currently in progress in applying the standard to the Electronic Combat facilities at Edwards AFB CA and Patuxent River MD. The program is also examining software modifications required to support range analysis work at Eglin AFB FL.

Finally, because there has been substantial investment made in existing models, i.e., legacy models, the program office is developing a bridge to allow customers to use these models. This means customers can use J-MASS tools to enhance the performance of existing models.

4 INTO THE FUTURE

Several key architecture improvements are planned in subsequent software releases. One will be to allow test engineers without an extensive software background to construct detailed models using a concept called "visual programming." Consider the case where an electrical engineer wants to design a circuit. J-MASS will provide a series of icons representing the parts of the circuit under design. "Behind" each icon will be the required code and the engineer will merely tailor the parts for the specific application. The J-MASS software will then link the parts to form the model. Thus, ***the code will flow directly from the engineering***. The benefit of standards such as the Software Structural Model is that they help engineers focus on their specialty and not on the programming aspects of M&S.

Another architecture improvement is the use of an "interconnect backplane". This allows the J-MASS architecture to be divided into components that communicate through the backplane. Users will be able to "plug and play" with only the components needed for certain applications. This improvement means it will be easier to use commercial off-the-shelf tools and to upgrade and replace other components. It also means improvements in simulation run time. By using the interconnect backplane, J-MASS will be able to distribute portions of the simulation across multiple heterogeneous processors in an optimized fashion. This improvement is critical for supporting real time applications of the architecture.

Over the next several years it is envisioned that a robust library will be populated with verified and validated modeling components and complete models to support DoD users from every discipline. These models, developed by several different organizations, will be interoperable and yield consistent and credible results because they have been built according to a standard.

While the J-MASS architecture was designed to support the engineering development, acquisition, and test and evaluation communities, flexibility will be added to insure models will operate with the Distributed Interactive Simulation (DIS) network. This will give J-MASS users greater flexibility in the use of their models while conserving limited funds.

5 SUMMARY

With reduced budgets, increased requirements to thoroughly test every concept, and an increased emphasis on virtual prototyping, the Defense Department will be relying more on M&S. The J-MASS program is developing the software standard and tools that will provide the means necessary to satisfy these demands and greatly improve the ability of M&S to meet user requirements. Through tri-Service participation, a system is evolving which will meet the needs of diverse modelers, analysts, and decision makers. Standard methodologies and reusable code will help keep the cost affordable and the open systems approach will insure the system is usable by the widest possible audience. J-MASS is providing an approach for DoD to improve M&S and realize the potential benefits.

AUTHOR BIOGRAPHIES

Lt Col David B. Russell is the Joint Modeling and Simulation System Program Manager and Chief of the Modeling and Simulation Branch, Electronic Combat SPO, Aeronautical Systems Center, Wright-Patterson AFB, OH. He has had a wide variety of operational and acquisition assignments over the past twenty years. These include assignments as an instructor and flight evaluator C-130 navigator with over 3200 flying hours, a staff officer at HQ Military Airlift Command responsible for flight management

and Aircrew Training Systems, and most recently as the Joint Program Manager for the AN/ALE-47 Countermeasures Dispenser System which recently transitioned to full rate production. Col Russell holds a Bachelor of Science in Engineering Technology from Memphis State University and a Master of Science in Operations Management from The University of Arkansas. He also holds Acquisition Professional Development certifications in Program Management and Test Management.

Mr William K. McQuay is Chief, EW Requirements Group, Requirements and Effectiveness Evaluation Branch, Electronic Warfare Division, Avionics Directorate, Wright Laboratory, Wright-Patterson AFB, Ohio. He has over 23 years Federal service and has worked in the Electronic Warfare digital simulation analysis area since 1972. He participates on several Air Force wide, Tri-Service and international groups for the development and utilization of EW digital simulation models, directs the Electronic Combat Simulation Research Laboratory (ECSRL), and is chairman of the J-MASS Architecture Technical Working Group. Mr McQuay has a Bachelor of Science (Mathematics), Towson State College; Master of Applied Science (Operations Research), Southern Methodist University; and Master of Science in Engineering (Computer Science), Johns Hopkins University.