Air Force Modeling and Simulation Trends

Modeling and Simulation Makes Possible the Unaffordable

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Modeling and Simulation (M&S) is already an integral part of the way the Air Force conducts business. Current use of M&S by Department of Defense (DoD) program and product managers extends throughout the Air Force; from research, development, acquisition, and sustainment, to training and operations (Figure 1).

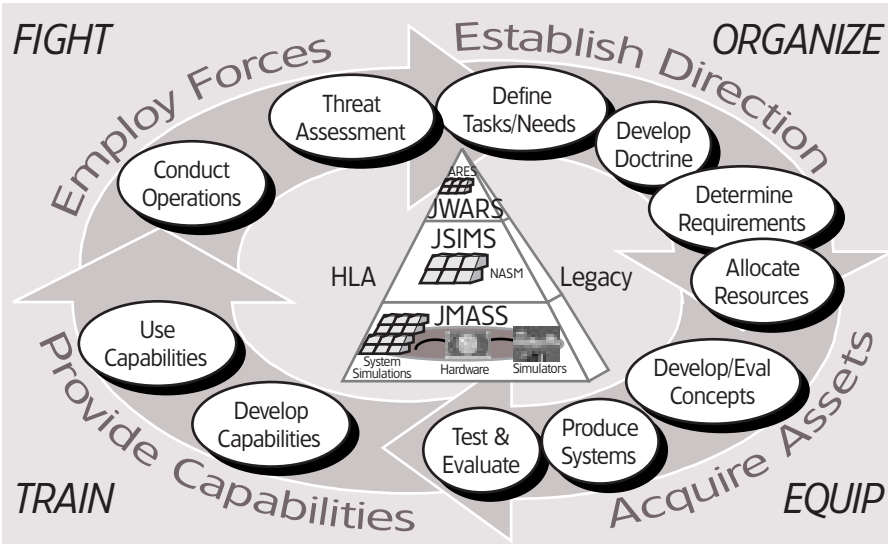

Figure 1. **M&S in the Air Force Enterprise**

The New M&S Vision

The Air Force envisions an integrated, common M&S environment that will be accessed by analysts, warfighters, developers, and testers supporting the range of Air Force tasks, from determining requirements through conducting operations. This article summarizes trends in the new vision for M&S and in the simulation technology that can be employed to implement simulation systems of the future. Joint M&S standards will provide key advanced technologies for future simulation applications.

Throughout the rest of the decade, the use of M&S will increase throughout all functional areas in the DoD. Because of increased technical capability and increased fiscal constraint, including DoD-mandated budget reductions in other areas, M&S utilization will continue to expand. Further, M&S allows DoD organizations to do things that would otherwise be unaffordable (i.e., thousands of parametric sensitivity tests on new systems) or physically difficult-to-accomplish military worth studies on proposed force structures against threat command and control systems).

Recognizing the importance of M&S, the Department issued a DoD Directive on "DoD Modeling and Simulation Management," that provides for a DoD M&S Master Plan. As part of the Master Plan, DoD established a common, High Level Simulation Architecture to assure not only the appropriate interoperability of simulations, but their interface with command, control, communications, computers, and intelligence (C^4I) systems. The goals of the High Level Architecture (HLA) include several areas:

- Interoperability
- Reuse
- Portability
- Distributed Operation
- Legacy Operation
- Scalability
- Broad Applicability
- Technological Evolvability
- Commercial Off-the-Shelf (COTS) Products
- Government Off-the-Shelf (GOTS) Products

DoD adopted the last two goals as part of its acquisition reform strategy to

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make maximum feasible use of off-the-shelf products.

Today's simulations are narrowly focused, stovepiped developments for each user community. Specifically, they do not fully meet Joint needs; take too long to build; cost too much to build and operate; lack verification, validation, and accreditation; are not interoperable with each other's M&S assets; and are not easily maintainable or extensible. High-level DoD and Air Force senior acquisition managers share a consensus view on the need to interoperate and reuse models, simulations, and related products across Service lines; across traditional communities (e.g., linking models and simulations to C⁴I systems); across functions (e.g., sharing capabilities between operations and acquisition); and across classes of models and simulations (e.g., linking live, virtual, and constructive simulations).

The effective use of models and simulations across DoD requires a common technical framework for M&S to ensure interoperability and reuse. Embodied in this technical framework will be a common HLA to which models and simulations must conform; conceptual models of the mission space to provide a basis for the development of consistent and authoritative simulation representations; and data standards to provide common representations of data across models, simulations, and C⁴I systems.

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Air Force program and product managers are in general agreement that no single model or simulation system can satisfy all uses and users. Further definition and detailed implementation of the specific simulation system architectures, which will be HLA-compliant, will remain the responsibility of the developing Service or Agency. The HLA will specify only the minimum definition required to facilitate interoperability and reuse. The DoD HLA is central to the M&S Master Plan.

One way to view this simulation HLA is to think of a city planner or architect. A building is compliant as long as

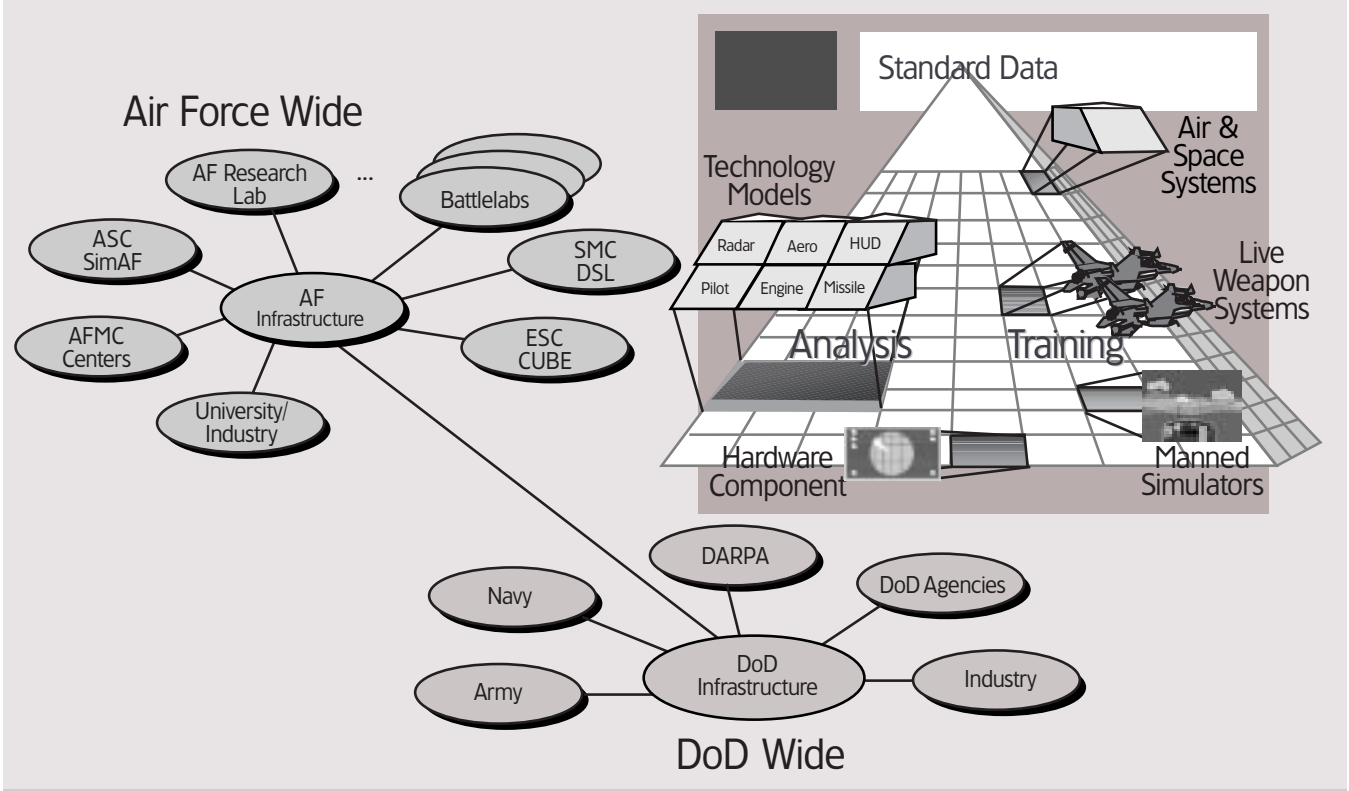

Figure 2. **Joint Synthetic Battlespace**

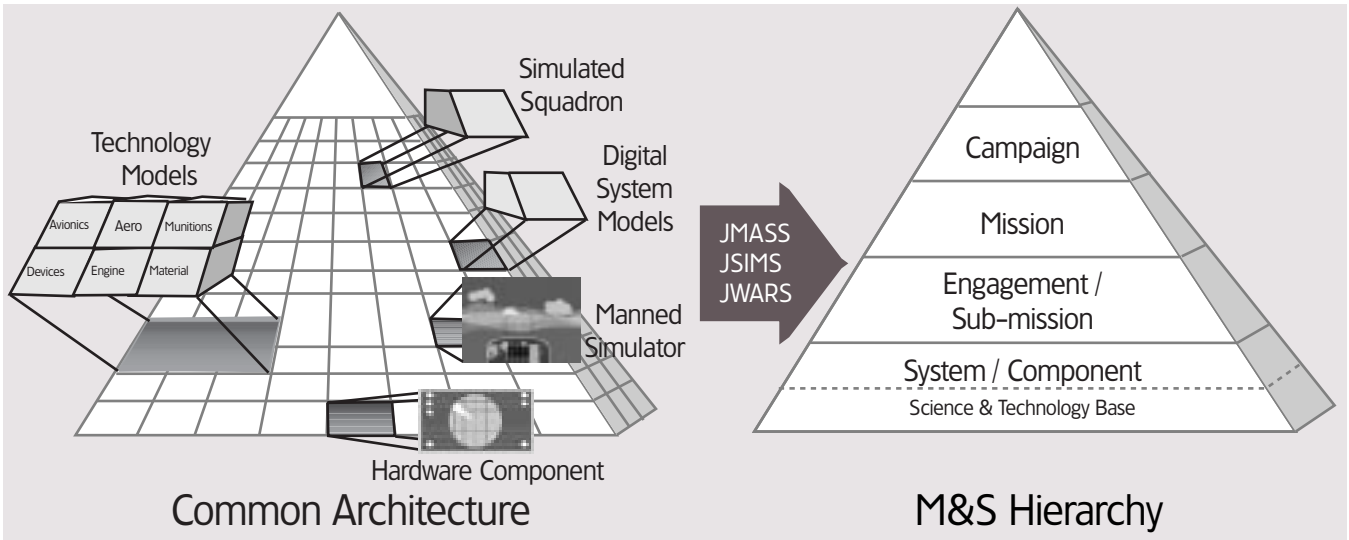

Figure 3. **The Air Force M&S Architecture**

you get the right permits and follow the building codes and standards. Similarly, new models would be required to follow specific standards to fit within a certain general architecture. The DoD M&S Master Plan and subsequent DoD directives require a review and oversight of all ongoing DoD M&S projects and programs for compliance with the HLA and phase-out of non-compliant programs by FY 01.

A New Vector for Air Force M&S

Consistent with the DoD vision, the Air Force envisions an integrated, common M&S environment accessed by analysts, warfighters, developers, and testers; and supporting the range of Air Force tasks, from determining requirements through conducting operations. On June 9, 1995, the Air Force convened an Air Force Four Star M&S Summit to create an M&S roadmap. The resultant roadmap defines a future vision for Air Force simulation and describes near-term and mid-term goals. Achievement of those goals is expected to move the Air Force closer to M&S commonality; and also a consistent representation of aerospace forces for Joint use.

The key concept in the Air Force M&S vision is the Joint Synthetic Battlespace – an integrated M&S environment, connecting analysis and training and tying together many types of simulation (Figure 2). The simulations extend from high-level aggregate models to detailed engineering models; from pilots in live aircraft and simulators, to hardware components and laboratory test beds.

The Air Force M&S infrastructure focuses on three key initiatives:

- **Joint M&S Integration Program (JMSIP)** – a coordinated approach to improving air and space representation in our legacy models and simulations while consolidating into fewer models that meet the requirements of many.
- **Joint Standards** – a commitment to Joint M&S developments with supporting Air Force initiatives.
- **Advanced Distributed Simulation Leveraging** – programs to provide high-speed connectivity between Air Force installations, multiple networked air combat training simulators for each wing in the Air Force, and a synthetic battlespace for Joint Force Air Component Commanders.

In the near-term, JMSIP will focus on the need to corporately address M&S improvements and the need to encourage consolidation. Addressing these two vital needs will serve as a leveraging effort, producing an Air Force M&S Roadmap that maximizes common efforts and targets improvements based on a corporate assessment of their importance and urgency.

For the mid-term and in accordance with overall DoD direction, the Air Force will implement simulation standards through defined architectures and simulation systems that support them. Each product center has or is developing a portal into the Joint Synthetic Battlespace of the future for *system of systems* evaluations and a key part of the current Air Force M&S infrastructure – Aeronautical Systems Simulation Analysis Facility (SimAF), Electronic Systems Command and Control Unified Battle Environment, and Space and Missile Center's Decision Software Laboratory.

In addition to key facilities, M&S standards will generate greatly improved simulation interoperability, allowing the Air Force to leverage simulation investments. The Air Force has targeted three major simulation standards efforts in the roadmap for high-level Air Force oversight and investment. All will participate and adhere to the DoD High Level Simulation Architecture initiatives being directed by the Director, Defense Research and Engineering, and managed by the Defense Modeling and Simulation Office:

- The Joint Simulation System (JSIMS) is a distributed, object-oriented simulation architecture and system focused on the *operational level of war* (campaign and mission level simulation).
- The Joint Warfare Simulation (JWARS) focuses on Joint campaign analysis.
- The Joint Modeling and Simulation System (JMASS) is an Air Force-directed program to develop and deliver a distributed, object-oriented simulation architecture and system focused on the *tactical level of war* (mission and engagement simulations).

These Joint standards and the systems that support them will enable interoperability and reusability of Air Force M&S tools across key communities and processes. The Joint standards serve as GOTS frameworks for the addition of third-party applications. These initiatives, coupled with ongoing improvements and standards, will bring the Air Force measurably closer to the objective of a common, integrated M&S system (Figure 3).

Computer and Simulation Technology Trends

The changes reported in this article and resultant revision in the DoD and Air Force M&S visions, motivated by changes in computer and simulation technology, reflect current trends throughout the DoD. In the past decade, computer hardware technology improved several orders of magnitude: microprocessor speed alone increased about 100-fold. The overwhelming trend is faster, smaller, and cheaper. This reduction in cost and size, coupled with an increase in speed and capacity, resulted in a massive increase in simulation capability. Computational power continues to increase as prices decrease.

As the decade moves on, *a multiprocessor on the desktop* will be commonplace for simulation and analysis. It will be accompanied by the continued decentralization away from the central site to distributed computing personal processors close to the user, mixed with computationally intensive servers on a heterogeneous network.

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Object-oriented (OO) software technology is having a major impact on simulation technology as well as software in general. For software developers, OO software addresses three major problems: iterative development, reuse, and maintenance. Since up-front requirements definition is difficult, many successful OO projects employed an evolutionary, iterative process for development. Object-orientation can also promote reuse through a library of reusable objects. When combined with reuse and visual programming, OO technology can increase productivity, and therefore lower cost and decrease time for software development.

Software development has been historically labor-intensive. To date, even computer aided software engineering tools have not dramatically increased productivity. Producing the needed improvement will require a major paradigm shift.

OO technologies, combined with visual approaches and an engineering discipline to software development via a software structural model methodology, can finally bring the needed breakthrough. OO technology will allow implementation of component-based software as the construct for software reuse. By employing component-based design, users can be divided into four roles:

- **Appliers** – configure input data and execute existing simulations.
- **Assemblers** – establish connections among component parts found in a reuse library to build simple custom applications or models without professional programming assistance.
- **Power Assemblers** – go beyond piecing component parts together by implementing more complex logic.
- **Fabricators** – build new component parts

Advanced User Interfaces will extend the now common Graphical User Interface into an agent-based multisensor user interface that will incorporate features such as voice synthesis and voice recognition. Future computer software architectures will incorporate Manager-Agent and Remote Programming. In Manager-Agent programming, the client computer sends an object that the server executes. The object is called an agent because it acts on behalf of the sending computer. In Remote Programming, the client and server can interact independently of the network once the network transports the agent to the server. These intelligent agents act like assistants rather than tools: they will show more initiative, assume responsibility for larger subtasks, and take appropriate risks (rather than confirming every detail with the user).

As computer and software technologies advance, they change the face of modeling and simulation. Simulation technology has evolved from stand-alone models, to model hierarchies, to an integrated modeling system (Figure 4).

Future advanced modeling systems will include the following characteristics:

- Open systems architecture supporting applications conforming to commercial and industry standards.
- Visual paradigm – visual programming, visual assembly, visualization of output results.
- Object-based to allow component reuse.
- Extensible architecture for future software concepts.
- Web-based, browser-type user interface on the desktop.
- Execution on distributed heterogeneous network of workstations and upscale PCs.
- Tools to support development of model components.
- Multiple language support – the user can specify the target source language (C, C++, Objective C, Java, Ada83, Ada95, VHDL, etc.).
- Object-oriented database.
- Tools and models support a "Plug and Play" concept.
- Supports "distributed model development" by the domain experts as opposed to central model development by software experts.
- Provide a repository of models and their components.
- Documentation designed to support software reuse.
- Verification, Validation, and Accreditation (VV&A) integral to the software development.
- Compliant with the DoD High Level M&S Architecture.

The future vision for Air Force simulation is a flexible, integrated simulation environment that supports the full range of Air Force activities. Revolutionary and evolutionary advances in computer and software technology provide significant opportunities to implement this modeling and simulation vision.

Summary

The future vision for Air Force simulation is a flexible, integrated simulation environment that supports the full range of Air Force activities. Revolutionary and evolutionary advances in computer and software technology provide significant opportunities to implement this modeling and simulation vision. The new M&S technologies will permit the creation of simulations tailored to the user's need, at a greatly reduced cost in time and money, and with elements of proven quality. Admittedly, achieving the simulation vision will require patience, perseverance, and significant investment to overcome many challenging problems, but the potential payoff is extremely high.

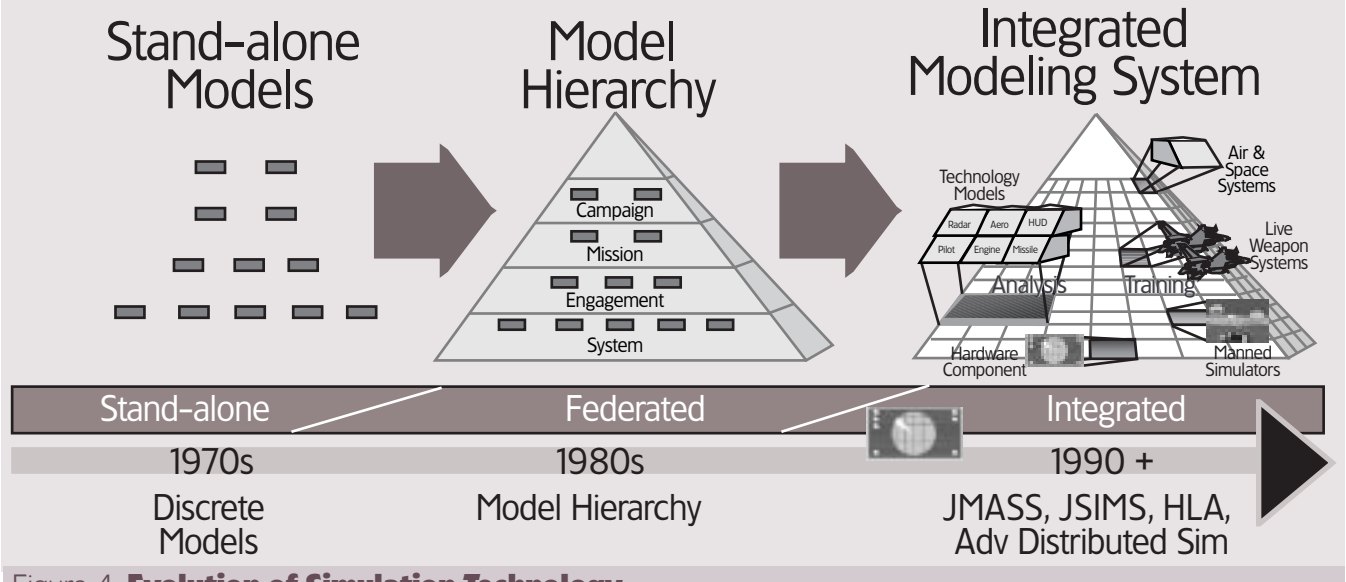

Figure 4. **Evolution of Simulation Technology**