NAVY AVIATION SIMULATION MASTER PLAN (NASMP): THE TRAINING ENVIRONMENT

Gary S. Kollmorgen
BMH Associates, Inc.
Norfolk, VA

Jonathan P. Glass
NAVAIR Training Systems Division
Orlando, FL

ABSTRACT: The Navy has an effort underway to examine a Navy Aviation Simulation Master Plan. Part of this plan will detail the Training Environment in which Navy Aviation Simulators will conduct training. Although NASMP is still in it's early concept stages, this paper will discuss the notional architecture of this environment and some of the distinct advantages.

Traditionally, the services, including the Navy, have procured simulators that have been an "all-in-one" device. That is, a "stove pipe" simulator/simulation designed to achieve training for aircrew in a single type aircraft/model. For the Navy, and in particular the Fleet Replacement Squadrons (FRS), this procurement model was generally sufficient for basic procedure training and novice tactical training. Post-FRS training is much more dependent on the trainer/trainee being able to interact with typical tactical environments (e.g., communications with E-2 and/or AWACS aircraft, tactics/communications with multiple "friendly" aircraft, etc.). This capability has been extremely limited with current simulators. The NASMP is working toward building an architecture in which possible legacy simulators and new simulators will be able to join to produce a rich training environment. This architecture will allow simulator developers to concentrate resources on building a robust simulator with the ability to federate into a training environment that will be shared among all simulators. This essentially gives the Navy the advantage of buying the best simulator while getting the simulation environment, networking, and training-control for "free." While there will be a cost to develop this environment, it will not have to be developed each time a new simulator is developed. Furthermore, it will allow relatively easy and inexpensive updating as new threat scenarios and entities are discovered and implemented.

AUTHORS' BIOGRAPHIES

Mr. Kollmorgen has over 15 years program management experience and over 20 years collectively in the development and application of campaign level simulation. He has an extensive background in U.S. Navy operations and has been responsible for providing expertise in weapons, engineering, and aviation related matters. He has provided subject matter tactical and technical expertise for the Knowledge Acquisition/Engineering (KA/E) design and validation of U.S. Navy Synthetic Forces (SF) for the DARPA STOW program, Joint Simulation System – Maritime (JSIMS), Joint Countermine Operational Simulation (JCOS) ACTD, Battle Force Tactical Training (BFTT) Air Management Node (AMN) and currently for the ONR WARCON program. Mr. Kollmorgen was also the project manager for establishing an authoritative and validateable representation of the Navy for Modeling and Simulation (M&S) applications through the SF KA/E process. Mr. Kollmorgen is BMH's program manager for NAVAIR's Navy Aviation Simulation Master Plan (NASMP).

Mr. Glass is a systems engineer with the Naval Air Systems Command, Training Systems Division, Systems Engineering Division, Aviation Systems Engineering Branch, in Orlando, Florida. He is currently supporting the NASMP O&I IPT. Mr. Glass has 12 years of experience in external systems engineering in both combat weapon systems and simulations. He is a graduate of the University of Central Florida (UCF) with a BS EE degree. Previously, he worked as the WARSIM C4I Technical Lead and as an Inertial Navigation Systems Engineer for the Naval Undersea Warfare Center in Norfolk, VA.

NAVY AVIATION SIMULATION MASTER PLAN (NASMP): THE TRAINING ENVIRONMENT

Gary S. Kollmorgen
BMH Associates, Inc.
Norfolk, VA

Jonathan P. Glass
NAVAIR Training Systems Division
Orlando, FL

HISTORY

Virtual simulators have proven to be an excellent addition to traditional in-flight training curriculum. Further, simulators provide for training that either can't be done in the real world (short of actual combat) or is too expensive to do with actual aircraft/weapons (live fire of precision guided weapons). The Navy Aviation Simulator Master Plan (NASMP) is developing an architecture and standards for interoperable simulators and simulations used to maintain Navy Aviation readiness through the Inter-Deployment Training Cycle (IDTC). The goal is to build a distributed, virtual simulator-based infrastructure of systems used to meet operational training needs of post-FRS squadrons, and eventually larger-scale joint service training.

OFT, WTT, TOFT, PTT

Simulators have been built, primarily for Fleet Replacement Squadron (FRS) training, to handle various levels of student training objectives and expertise. Operational Flight Trainers (OFT) are generally used for procedures training and basic tactical training (see Figure 1). Weapons and Tactics Trainers (WTT) and Weapon Systems Trainers (WST) are generally used for weapons systems and tactics training and may have limited basic/emergency procedure capability (see Figure 2). Tactical Operational Flight Trainers (TOFT) are more of a universal trainer providing procedure and tactical training capabilities (see Figure 3). Part Task Trainers (PTT) are generally developed to train in a limited area, such as a specific weapon capability. Finally, there are a host of “simple” trainers that have been developed for very specific training, such as emergency procedure “knob-ology,” and have limited or no flight or tactics capability. The NASMP is focusing on post-FRS training and, therefore, is most interested in OFT, WTT, and TOFT type trainers. However, other trainers can be considered if they have the technical capability to interface into the NASMP infrastructure and satisfy a training requirement not satisfied through other means.

Figure 1 – EA-6B OFT

Figure 2 – E-2C WST

Figure 3 – F-18E/F TOFT

Limitations

There are several limitations to existing simulators when attempting to apply them to a distributed mission training environment such as desired for the NASMP. Technical limitations of existing simulators make them less than ideal for networking.

Many legacy simulators are limited to “out of the cockpit” image generation (IG) limits. That is, they can only accept a number of “targets[1]” equal to the capacity of their IG. In some cases, this is as few as five targets. Further, existing simulators have a limited choice for those targets. While the target types may be near 100 or more, often there are severe limitations in certain types, such as only one ship type and one or two ground vehicles (the bulk of targets being aircraft types). In addition, adding new targets, as new threats are discovered/developed in the real world, is often expensive[2] or nearly impossible because of software architecture limitations.

Another existing limitation is operating areas or terrain maps. Legacy simulators have few operating areas to chose from, making them limited in mission rehearsal capability for areas anywhere in the world. These limitations are not a problem in the FRS training environment[3], but distributed mission training requires flexibility in the operating area.

There are several “fair fight” issues that make legacy simulators less than ideal for distributed training. Some existing simulators do not interact with terrain. That is, they are capable of flying through mountains and sensing (weapon sensors) as well as shooting through any obstructions. Additionally different manufacturers of simulators have provided varying capabilities to their threat systems. Adversary targets intercept capabilities and weapon fly-outs vary in sophistication from one simulator to another. For example, threats in the F/A-18 simulators are generally more sophisticated due to the nature of the F/A-18 mission. However, similar threats in the E-2C simulator are not as sophisticated because of the mission of that aircraft.

Finally, there are non-technical issues with legacy simulators that generally evolve around availability. Many existing simulators are currently used at capacity to support current FRS training requirements. While they may be capable of supporting distributed training, it would be unlikely that they could provide the usage opportunity for post-FRS distributed training.

THE “PIECES”

There are four major pieces to the distributed mission training environment envisioned by the NASMP. They are addressed below and are highly dependent on each other to provide a robust and seamless training environment. The standards defined here will aid the simulator developer in producing a simulator that can easily integrate into this distributed environment and also provide an opportunity to leverage off of the NASMP provided tools to lower cost and production time of new, more capable simulators.

Network

The Network requires definition so simulator vendors know what is available “on the wire” and how they are to talk across the network. Standards are required to address protocols, addressing schemes and other networking related issues. Future NASMP developers and simulator vendors need a clear understanding about what will be provided and what needs to be provided.

---

[1] Targets, in this case, are any simulated entities the simulator can see through its out of the cockpit images or through its weapon sensor system. Entities can be ships, aircraft, vehicles, buildings, etc.

[2] Separate development efforts are required to add the new threats for each simulator.

[3] These shortfalls were not considered a limitation when these simulators were manufactured. The simulators met existing requirements of their time but fall short when trying to insert them into the NASMP training environment.

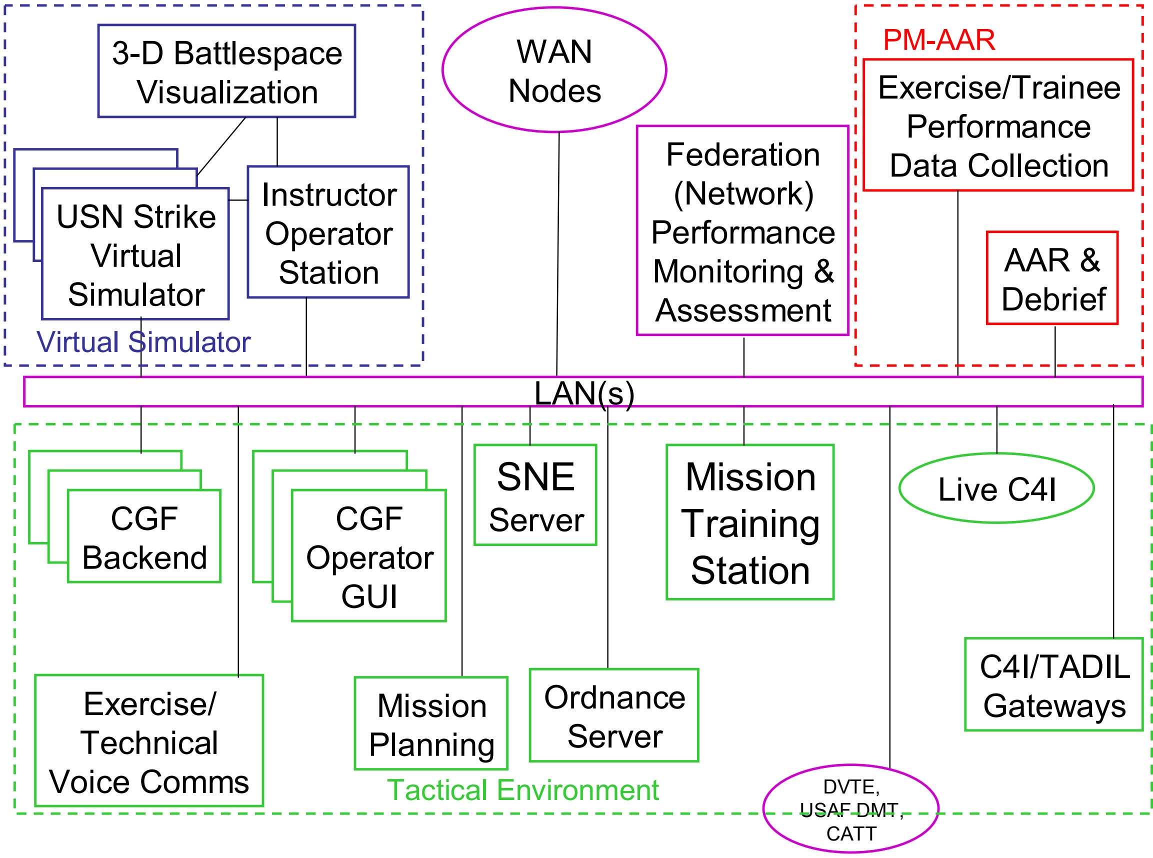

Figure 4 - NASMP "Notional" Architecture

Tactical Environment

The Tactical Environment addresses the applications required to perform distributed mission training. Operator control stations, computer generated forces, scenario generation and synthetic natural environments are just a few of the applications that will be required to operate a distributed mission training scenario. Standards for these tools need to be developed to address networking protocols in order to ensure network compatibility and to deal with database generation in the case of computer generated forces.

Visual Systems And Databases

Databases need to be developed for multiple applications. But, the key is the databases must be correlated so all visual, sensor, threat and environment data matches. A standardized process needs to be defined to allow quick database generation to allow for mission rehearsal anywhere in the world. The process has to be robust and supportable by natural environment generators, simulator image generation and weapons systems developers, and computer generated force developers.

Performance Measurement – After Action Review

Performance Measurement and After Action Review are the tools that bring all of the operational pieces together. Standards will be defined to address metrics that need to be captured for performance measurement and after action review. Hardware/software solutions will be explored and refined to allow for display of real time performance as well as after flight grading. Additionally, play back of the entire immersive environment will allow complete review of individual crewmember, aircrew team, individual aircraft, section, or flight as required.

THE “NOTIONAL” ARCHITECTURE

The NASMP “notional” architecture (see Figure 4) shows the component parts required to perform a distributed mission team training scenario. The blue dashed box represents the Virtual Simulator components, the green dashed box represents the

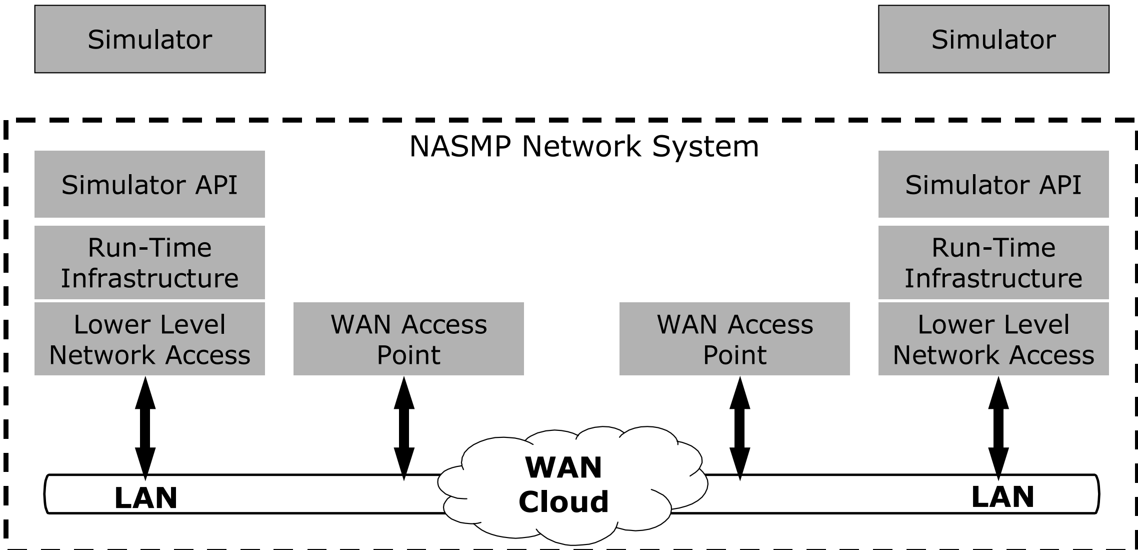

Figure 5 – NASMP Network Interface Points

Tactical Environment components, the red dashed box shows the performance monitoring and after-action review components, and the purple elements comprise the Network components.

WAN/LAN

The Networking components include all hardware/software up to the simulator application programming interface (API) (See Figure 5). The networking protocols that will be used need to be defined for the simulator developer and need to support the Tactical Environment, Performance Monitoring and After Action Review tools defined by the NASMP. Networking considerations include existing infrastructures at Naval Air Stations, commercial versus government provided wide area network (WAN) connectivity and/or administration, and, currently, the installation schedule and support of the Navy Marine Corps Internet (NMCI). The tools picked to run over the network will affect the Run Time Infrastructure (RTI) selections which will affect hardware chosen for network interface cards (NICs) as well as routers and switches (ATM, multicast, etc.). Costs are a large factor in a major program and networking costs are crucial. Bandwidth requirements have to be determined and provide the basis for networking recurring costs. Additionally, manpower costs will have to be determined to support installation, maintenance and control of the networking for the NASMP events.

Virtual Simulators

Virtual Simulators are basically self-explanatory. Their capability is crucial to the NASMP success. They are the man-simulation interface. Manufacturers of simulators need the standards being defined by the NASMP to determine the interfaces and data flow between their simulator and the NASMP environment. Further, it is possible for the simulator developers to leverage off of the NASMP environment by using the tools (CGF, control stations, PM-AAR) provided by NASMP to run their simulator in a stand alone mode as well as when running in a distributed environment. Vendors will also need to have an appreciation for the concept of operations (CONOPS) envisioned by the NASMP. The CONOPS will provide information such as usage rates, single ship versus multi-ship usage, initialization, tool operations, etc.

Computer Generated Forces (CGF)

CGF provides the “threat” or “targets” for the virtual simulators. Standards here affect data flow to and from the virtual simulators. Decisions here also affect networking protocols, existence of support tools such as mission planning and scenario generation, and synthetic natural environment support and database development. CGF also have a large impact on “fair fight” issues that will be discussed in more detail below. Additionally, CGF provides the number and types of entities that can be used in a distributed training environment. CGF “Backends”[4] will be used to provide the processors that run the different entities. CGF Operator Graphical User Interfaces (GUIs) will be used to control entities and provide role player stations.

Databases

Databases are used to represent the 3D world to the cockpit image generation systems, to represent the terrain and cultural features of the synthetic world to the CGF, to provide threat information to the virtual simulator onboard weapons systems, and to provide natural environment input (weather, time of day, etc.) to the synthetic battlespace. These databases must correlate to provide a single accurate picture to the aircrew. Further, these databases must be generated easily to account for mission rehearsal capability anywhere in the world. While NASMP will be responsible for CGF databases, simulator vendors will have to be able to generate visual and weapon system databases that correlate using the same data or the same source data. Standards need to be defined to provide the process to generate, test, and distribute these correlated databases.

Mission Training Station (MTS)

The MTS is a graphical user interface (GUI) that is used to develop scenarios; configure federation resources for training exercises; initialize a federation exercise; monitor an exercise execution using 2-D plan view displays; terminate a federation exercise; initialize, monitor, and control CGF entities; monitor the performance of individual federates during exercise execution; monitor the performance of the network(s) during exercise execution, and configure and control the federation servers. The MTS will provide the heart of the distributed mission training environment execution. Standards will help define what services are provided to the virtual simulators as well as the performance monitoring and after action review systems.

Servers

Servers are specialized processors on the network that provide common and correlated data to other simulation components. Examples include Synthetic Natural Environment (SNE) servers and weapon/weapons servers. A Weapons Server can host air-to-air, air-to-ground/surface, ground-to-ground, and surface-to-air guided weapon simulations and is capable of supporting multiple, simultaneous guided weapon fly-outs. It can provide support to fair fight issues by providing a common set of weapon simulations (that is, simulator A’s weapon is no different from simulator B’s weapon) that can be employed by the NASMP virtual simulators and CGF.

PM/AAR

Student Training Objectives (TOs) will be defined before the NASMP training exercise in order to support the NAMSP Scenario Planning process. The student’s TOs will be identified from several sources to include the student’s Electronic Training Jacket (ETJ), Navy Mission Essential Tasks (NMETL) and required Training and Readiness (T&R) Matrix qualifications sought. The performance measurement planning system utilizes the information from the Scenario Planning system and the TOs to generate the required data capture and trigger events to assist the instructor. Interoperability with existing Navy Training Management Systems / Learning Management Systems (TMS/LMS) and T&R reporting systems such as TEAMS, SHARPS, SFTS, ACOL LMS etc, is required by the NASMP.

Data Collection provides access to the data necessary to facilitate the monitoring of the NASMP training events and the assessment of performance and effectiveness of the mission specific tasks. Data Collection also supports the NASMP training exercise processes (i.e. Planning, Brief, Debrief and AAR).

AAR encompasses all the activities necessary to review and assess training performance over the course of the training exercise. Typical data formats and protocols such as video, audio, High Level Architecture (HLA), Distributed Interactive Simulation (DIS), mission planning data, graphics, etc, will be addressed by the NASMP standards.

C4I

Command, Control, Communications, Computer and Intelligence (C4I) systems, mainly tactical situation type displays such as the Global Command and Control System – Maritime (GCCS-M) will be used to support large scale NASMP training exercises that involve warfare commander personnel who would normally be located in a command center or tactical operations center. The use of C4I also provides an interoperability mechanism between the NASMP federation and live Fleet units such as might be required to support Fleet training that is performed during

[4] Backends – computer processors and memory that are used to run simulation entities but are controlled by a separate “Frontend” PC processor GUI)

Fleet Battle Experiments and joint warfighting exercises. Additional voice communications are necessary to provide the capability for the aircrew who man the NASMP virtual aircraft simulators, the MTS operator, Entity Station pilots, CGF operators, role players, and instructor personnel to communicate with each other, as required, in order to plan, initialize, execute, terminate, and debrief a training exercise. These voice communications also provide the means for the aircrews in virtual simulators to conduct tactical communications with other aircrew, Entity Station pilots, CGF operators and Role Players.

USAF DMT, MCASMP, USMC DVTE, Etc.

The NASMP also has a requirement to be able to "join" other service federations to enrich the synthetic battlespace and enhance the training experience. Current programs that the NASMP is following are the U.S. Air Force's Distributed Mission Training (DMT) program, the U.S. Marine Corps' Aviation Simulator Master Plan (MCASMP), the U.S. Marine Corps' Distributed Virtual Training Environment (DVTE) program and the Joint Simulation System (JSIMS) program. The NASMP intends to use industry standards (e.g., IEEE 1516 – HLA, TCP/IP, UDP, Multicast, etc.) to allow expansion and leveraging of other programs as they are developed into the future.

THE ADVANTAGES

"Fair Fight"

"Fair Fight" is being "built into" the NASMP environment from the ground up. Fair fight is necessary for a realistic training experience as well as for validation of the training environment. Fair fight assessment will be performed at the physical and mission behavior levels. Fair fight at the physical level is directly observable in real-time; however, fair fight at the mission behavior level is only indirectly observable in real time for CGF through visualization applications and the CGF user interface. As the NASMP proceeds, it will evaluate which CGF will provide the best representation for threats, friend and neutral agents.

Monitoring and evaluation are important tools to improve simulation effectiveness. Monitoring is defined as a regular reporting mechanism, preparing and submitting analytical assessment to project management and other involved parties. Monitoring enables M&S managers to identify and assess potential problems and success of a program or project. It provides the basis for corrective actions to improve the program or project design, manner of implementation and quality of results. In addition, it enables the reinforcement of initial positive results. In order to evaluate the effectiveness of the defined NASMP training objectives an established process is required for performance monitoring.
A monitoring and evaluation system will work with combat planning procedures for mission level rehearsals. Any database (terrain, threat, electronic warfare, etc.), and its monitoring, evaluation and validation system, should provide warfighters with complete and accurate information easily accessible through available applications and be presented in a comprehensive and useful way.

Undoubtedly, there may be areas where discussions arise on whose model is best and why or why not. The subsequent model evaluations should be a systematic review and analysis for:

- Relevance to objectives
- Efficiency in simulation and network operation
- Effectiveness in achieving training audience results
- Impact on overall objectives
- Sustainability over time

Model Additions

An offshoot of the NASMP architecture is the ability to add additional models easily and cost effectively. Legacy simulations require that new models be added to each simulator often requiring significant rework of the models to fit the software/hardware architecture of the simulator as well as the language requirements. With the composable nature of the NASMP architecture, new models are easily added and, possibly, may be Plug-n-Play for the virtual simulators. Models can be added through the NASMP CGF or through the NASMP servers. Thus, once a model is added to either the CGF system or appropriate server, it is available to all networked virtual simulators.

This ability will minimize the fair fight issues as to whose model is best described in the previous section. However, the same sort of analysis should take place to determine the source of the model that will be added to the NASMP environment.

Servers

As discussed above, "servers" will be evaluated and most likely used in the NASMP environment.

Servers allow for fair fight through the use of common models and provide for efficient introduction of new models through the server architecture. Using servers helps ensure "common" models and data are employed by the virtual simulator and CGF entity processes in the federation. This is accomplished by either using a centralized process or by using common models and data that are distributed and hosted by each virtual simulator, CGF, or natural environment process that requires a common capability to interact in the synthetic battlespace. Additionally, this provides a leverage opportunity for the simulator vendor to use these common models as opposed to building his own.

Validation

As with "Fair Fight," and closely related models, validation is being "built into" the NASMP environment. The NASMP standards will require the virtual simulator vendor to provide mappings of data elements to demonstrate correlation between source data and their runtime components. This will provide the basis for validation and assist in coordination with other data users (e.g., datasets for visual with the corresponding representations for CGF). Additionally, the simulation vendors will provide a verification and validation process to demonstrate that their design meets the interoperability requirements of the NASMP.

Interactions between the virtual simulator and CGF will be just as important as the interaction among the CGF players. While simulator vendors are encouraged to maximize reuse of the NASMP provided tools, it may be possible to have multiple CGF within the NASMP environment (e.g., the NASMP CGF and a virtual simulator provided CGF). Therefore, the CGF interaction validation must consider behaviors, communications and the interfaces among the network participants.

NASMP will require Verification and Validation reports (V&V). The V&V reports are being designed to contain a narrative summary as well as a set of specially developed profiles, which enables easy horizontal and vertical comparison of entities as well as overall unified assessments. They serve as checklists for first and subsequent validations as entities are modified, added or deleted, as well as potentially providing an effective early warning for interaction (re: Fair Fight) anomalies.

The advantages of using these types of validations for databases and procedures should be to provide common verification points that are clear and complete to facilitate accreditation across the spectrum of simulation entities. A robust V&V capability will provide quantitative and qualitative data that can serve as inputs to evaluation exercises. Evaluation of the entity data also supports validation by serving as a source of lessons that can be applied in the development of conceptual or doctrinal innovations for future concepts.

STATUS

The NASMP technical analysis started in earnest around the first of the calendar year (2002) with the award of multiple contracts. Significant progress has been made in the subsequent eight months (as of the writing of this paper). Some of the highlights are noted below.

Site Surveys

A team of Government personnel and Contractors have visited most of the CONUS Naval Air Stations to determine the current capabilities (the "as is") of these sites to support the NASMP environment in the future. The simulator sites are being visited to determine the network, space, and current capabilities of the virtual simulators. These site surveys will help determine which possible legacy simulators, if any, have a technical capability to be networked into the NASMP environment and have the usage availability (i.e., the simulator is not currently 100% utilized to fulfill existing training requirements). Additionally, the sites are being surveyed for availability of space to house the additional hardware capability required to support the NASMP distributed training and operational rooms necessary to execute this training. Finally, the sites are being surveyed for existing network infrastructure to determine existing capability to support distributed training as well as to assist in costing network additions to support distributed training. Draft site surveys for the Strike Package aircraft[5] are complete while site surveys for ASW aircraft[6] are being currently executed.

Requirements Development

Another team of Government personnel and Contractors are visiting the Naval Air Stations to determine the NASMP requirements. Training Officers and Naval Aviators are being canvassed to determine requirements for the NASMP as well

[5] Defined here as the F/A-18 (all models), E-2C, EA-6B, and EP-3.

[6] Defined here as the SH-60B/F and P-3C

as identify training shortfalls of current training systems. Analyses of these visits will help define the type of simulators needed to achieve the post-FRS training objectives (e.g., laptop simulators, part task trainers, full motion trainers, etc.). Some preliminary results are being analyzed, but the requirements process is still work in progress.

Standards Definition

A key to getting the environment defined and to provide the necessary information to virtual simulator vendors is to provide a NASMP interoperability standards document. This document (currently in draft form) helps define the architecture as discussed above, the standards being applied to that architecture, and the requirements being levied on the simulator vendors. As more tools and costing information are determined (see test bed discussion below), the standards will become more refined.

Test Bed

While the draft NASMP interoperability standards document discusses much of the known standards (e.g., HLA), it does not have the benefit of having the applications defined for all of the various components of the NASMP architecture. These components must interoperate, thus using tools that adhere to industry standards is weighted heavily in the NASMP tool determination process. A test bed is being stood up to facilitate and support the further testing and analysis of existing tools to determine the first NASMP tool set. This test bed will include the Naval Air Systems Command, Training Systems Division (NAVAIR TSD), Naval Air Systems Command, Pax River, and L-3 Communications (L3COM) the prime contractor doing the analysis on tool determination

SUMMARY

What's in the future? Additional site surveys with overseas simulator facilities are being added to the scope of the NASMP. The NASMP requirements continue to be analyzed and defined. Cost estimates are being developed based on the current NASMP defined architecture and CONOPs. These estimates will include life cycle hardware, software, and personnel costs. Testing of existing and developing tools is continuing through the summer of 2002 in the NASMP test beds. A possible NASMP long haul network is being looked at for the end of CY 02 for preliminary testing and analysis. Distributed training Multi-Level Security (MLS) solutions are being explored. There is still work to complete in order to allow the NASMP to move into an execution phase starting in 2003.

The NASMP is an ambitious project with the ultimate goal of providing improved simulation based training for all aspect of Navy Aviation. It intends on achieving these goals through a rich requirements generation process, a thorough understanding of distributed networking industry standards, and a cost savings through maximum reuse of existing tools and technologies. Training effectiveness will not be compromised through reuse, rather will be enhanced by bringing to bear the "best of the best" in tools and technologies. Further, the NASMP has attacked the problem in a very systematic way. By developing the standards and architecture up front, virtual simulation vendors have a clearer understanding of what is expected of them and what will be available through the NASMP training environment. Although legacy simulators are being investigated for federation into the NASMP environment, it is well understood that this distributed environment was not envisioned when they were designed and built and noticeable shortcomings are expected. The NASMP is a path to the future more than an enhancement of past simulator development. Early defined Requirements, Standards, and Architecture are a strong foundation for the successful future of Navy Aviation training.

REFERENCES

NASMP Interoperability Standard, Draft 0.2, 5 JUN 02

IEEE Standard P1516 – High Level Architecture Framework and Rules

IEEE Standard P1516.1 - High Level Architecture Federate Interface Specification

IEEE Standard P1516.2 - High Level Architecture Object Model Template (OMT) Specification