INTEGRATION OF COMMON M&S RESOURCES FOR TEST AND TRAINING RANGES

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ABSTRACT

Guidance from the Office of the Secretary of Defense (OSD) in the form of the Joint Test and Training Range Roadmap (JTTRR) attempts to merge and leverage test and training range efforts where feasible. A multi-year effort being performed under the Office of the Director, Operational Test and Evaluation (DOT&E) CROSSBOW program is providing for the concurrent integration of common weapon simulations into architectures which support real-time live-fly exercises on the open air ranges (OARs) and into a high fidelity integrated air defense system (IADS) model. The real-time surface-to-air missile (RTSAM) models, which are being developed and validated under the cognizance of the Defense Intelligence Agency/Missile and Space Intelligence Center (DIA/MSIC) in Huntsville, Alabama, are related to those being developed under OSD's Joint Modeling and Simulation System (JMASS) Program.

Information regarding the mission and purpose of the CROSSBOW committee is provided, followed by a description of the RTSAMs and their specific relation to the JMASS Program. The individual integration efforts are then discussed in detail, with primary emphasis upon the integration in support of real-time OAR exercises. Topics discussed include system and subsystem requirements definition, concept of operations (CONOPS) development, porting/verification of software to the selected computer platform, development of software utilities necessary to represent site-specific operation, and comparative validation efforts following integration.

ABOUT THE AUTHOR

Mr. R.H. Taylor is a member of the Technical Staff for the Florida Office of Dynetics, Inc. Since graduating from the University of Missouri-Rolla and joining Dynetics in 1987, Mr. Taylor has participated in systems engineering and analysis efforts utilizing digital simulations, hardware-in-the-loop simulations, installed system test facilities, and open-air flight tests. In recent years, the majority of Mr. Taylor's activities have centered upon the employment and evaluation of real-time simulations in aircrew training applications. Mr. Taylor is currently supporting the 29th Training Systems Squadron (29TSS) of the Air Warfare Center's 53D Wing at Eglin AFB, FL, with the development and execution of methodology to assess both independent and networked aircrew training devices for the F-22 Raptor.

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INTRODUCTION

Guidance from the Office of the Secretary of Defense (OSD) in the form of the Joint Test and Training Range Roadmap (JTTRR) attempts to merge and leverage test and training range efforts where feasible. A multi-year effort being performed under the Office of the Director, Operational Test and Evaluation (DOT&E) CROSSBOW program is providing for the concurrent integration of common weapon simulations into architectures which support real-time live-fly exercises on the open air ranges (OARs) and into a high fidelity integrated air defense system (IADS) model.

THE CROSSBOW COMMITTEEE [1]

The Threat Systems Office acts as the independent oversight and management staff for the Office of the Director, Operational Test and Evaluation / Resources and Ranges (DOT&E/RR) on all activities related to the DoD Threat Systems Program. The mission of the Threat Systems Office is to support DOT&E and the DoD Defense Test and Training Steering Group (DTTSG) for all DoD activities related to planning, programming, budgeting, management, acquisition, development, and validation of threat system representations used in T&E and training. The principal DoD threat system areas are provided in Figure 1.

Foreign Material Program
Threat Simulation Program
Threat Representative Targets Program
Threat Modeling and Simulation Program
Threat Simulation/Target Validation Program

Figure 1. Principle DoD Threat System Areas

Among its many functions, the Threat Systems Office chairs the DOT&E-chartered CROSSBOW Committee. The mission of the CROSSBOW Committee is to provide technical and management oversight of the Services' development and acquisition programs for threat and threat related hardware simulators, emitters, software simulations, hybrid representations, and surrogates. The purpose of the simulator development and acquisition program is to support Developmental Test and Evaluation (DT&E), Operational Test and Evaluation (OT&E), and training. In addition, the CROSSBOW Committee provides funding for technical investigations and/or workshops on critical foreign technology approaches leading to the development of threat simulators. The Committee assimilates the Services' threat simulator development and acquisition programs (including simulator developments required to support special access programs), as well as CROSSBOW Committee funded projects for presentation to the DTTSG for review and approval.

The CROSSBOW Committee membership is comprised of the Chairperson and one representative and an alternate from the Department of the Army, the Department of the Navy, the Department of the Air Force, and the Defense Intelligence Agency (DIA). Observers include one representative from the following agencies: Office of the Under Secretary of Defense (Acquisition and Technology), Deputy Director, Test, Systems Engineering and Evaluation; Office of the Director, Operational Test and Evaluation; National Security Agency (NSA); Central Intelligence Agency (CIA); Joint Staff; Ballistic Missile Defense Organization (BMDO); Joint Targets Oversight Council (JTOC); Joint Program Office (JPO) for Test and Evaluation/Board of Operating Directors (BoOD); and Electronic Warfare Test Resource Office (EWTRO). Representatives from the Services' Scientific and Technical Intelligence (S&TI) centers are invited as required to serve as liaison between the Committee and their respective agencies and to assist the Committee in obtaining information required for planning purposes.

DEVELOPMENT OF REAL-TIME SURFACE-TO-AIR MISSILE (RTSAM) MODELS

Virtual simulation tools to be employed by the F-22 and Joint Strike Fighter (JSF) programs (the F-22 Air Combat Simulator and JSF Virtual Strike Warfare Environment) require credible surface-to-air missile (SAM) models that execute in real time. These models will be used to evaluate weapon system survivability on offensive counter air missions, such as force protection, fighter sweep, suppression of enemy air defenses, etc.

DoD policy requires the intelligence agencies, through the Defense Intelligence Agency, to either develop the models and/or substantiate their credibility. As the current Joint Modeling and Simulation System (JMASS) efforts being pursued by the Missile and Space Intelligence Center (MSIC) do not fully support real time execution, development of real-time surface-to-air missile (RTSAM) models has been initiated. Multiple RTSAM models required for the F-22 and JSF virtual simulations are being developed under a Resource Enhancement Project (REP) funded under DOT&E/RR's Central Test and Evaluation Investment Program (CTEIP). The RTSAM models, which are derived from JMASS98 analytical models, are being developed, verified, and validated under the cognizance of DIA/MSIC. The procurement includes models of the fire control radars, the firing units, and missiles for each of the SAMs.

A "WIN-WIN-WIN" OPPORTUNITY ARISES

Obviously, many organizations other than those associated with the high-profile F-22 and the JSF efforts have programs that require credible surface-to-air missile (SAM) models that run in real time.

The Airfield, Airspace, and Range Management Division of HQ ACC/DOR provides for the improvement and maintenance of tactical training range capabilities across the Combat Air Forces (CAF). This is accomplished largely via provision of requirements and funding to the Range Instrumentation System Program Office (RISPO), Air Armament Center, (AAC/WMRR), at Eglin AFB, FL. The training range community currently possesses an interoperable infrastructure known as the Air Combat Test and Training System/Tactical Aircrew Combat Training System (ACTTS/TACTS) for execution and display of weapon simulations in support of the joint warfighter (Air Force, Navy, Marines, and Army). However, due to fiscal constraints, the existing library of ACTTS/TACTS weapon simulations has become increasingly suspect and credibility of simulation results with the joint warfighter has eroded. In addition, the simulations are of modest fidelity and do not necessarily represent threat system performance across mission areas. Current ACTTS/TACTS capability is interoperable execution/display of weapon simulations with an existing library of suspect/non-validated threat models.

The Digital Integrated Air Defense System (DIADS) is a resource of the 412 TW/EWW, Air Force Flight Test Center (AFFTC), at Edwards AFB, CA. DIADS is high fidelity model of the threat Integrated Air Defense System (IADS). The Air Force Information Warfare Center (AFIWC) is using DIADS to meet their need for a high fidelity IADS simulation (calling their version of DIADS the Command and Control Warfare Analysis and Targeting Tool, CATT). The DIADS provides simulation of a mission level threat IADS to include the early warning, ground control intercept, and airborne surveillance radars, command and control systems, passive detection, and SEAD. DIADS has no validated capability to provide terminal threat system effects. The DIADS will be a validated test capability used to provide penetrability analysis, situation awareness evaluation and combined forces testing in a mission level environment. It will reside at Edwards AFB, CA as part of the Avionics Test and Integration Complex (ATIC). High fidelity test assets at the open air range are being modified to provide DIADS compatible, synthetic targets and ground clutter (either real clutter from the range or National Imagery and Mapping Agency (NIMA) derived synthetic clutter). DIADS achieved HLA compliance certification in May 1999 and is particularly well suited for large, distributed defense scenarios. It can be linked via DIS/HLA to operational assessment facilities like Battle Labs or test and evaluation facilities. DIADS currently includes terminal threats that are low fidelity and not validated.

The RISPO submitted a FY00 proposal to the CROSSBOW Committee calling for the integration of the DIA/MSIC RTSAMs into their training system resource (ACTTS/TACTS). Concurrently, the 412 TW/EWW submitted a separate FY00 proposal calling for the integration of the DIA/MSIC RTSAMs into their test range resource (DIADS). Eventually, a joint proposal [2] emerged that provided for the *common integration of validated threat weapon simulations (the RTSAM models) between the test and training communities*, resulting in:

- A substantial enhancement in aircrew training capabilities for the joint warfighter (Air Force, Navy, Marines, and Army) via incorporation of validated threat models into existing training range architecture.

- A pre-planned product improvement to provide DIADS capabilities for the Air Force, Navy, Army, and DIA that supplements the current Air Force capabilities to test modern systems.

RTSAM INTEGRATION INTO TRAINING RANGE ARCHITECTURE

While managed as a single joint program under the cognizance of the Threat Systems Office, execution of the integration efforts are performed individually by the respective organizations. The remainder of the discussion will focus upon the planned integration of the initial two RTSAMs (the SA-10A/B and the SA-20 systems) into the ACTTS/TACTS training range architecture.

Each integration effort (i.e., the individual efforts to integrate each of the eight models projected) will require the performance of activities that may be categorized as management, porting, integration, and test. The specific items shown in Figure 2 will serve as the basis for the detailed discussion that follows.

ACTTS/TACTS INFRASTRUCTURE

The fundamental infrastructure for ACTTS/TACTS consists of the three major subsystems: the Tracking Instrumentation Subsystem (TIS), the Computation and Control System (CCS), and the Advanced Display and Debriefing Subsystem (ADDS). These systems provide all of the control, processing, data storage, and displays for ACTTS/TACTS.

The TIS consists of one or two master stations and several remote interrogator stations. The remote interrogator stations consist of surface-to-air-to-surface and surface-to-surface receiver/transmitters normally powered by batteries, which in turn are normally charged by solar panels. The remote interrogator stations receive master station transmissions for relay to all instrumented aircraft on a range and then receive air-to-surface transmissions from the instrumented aircraft for relay back to the master stations(s). The master stations consist of a controller-processor computer for controlling ranging and data communications functions, two-way datalink equipment for communications with the CCS, a transmitter/receiver to provide ranging signals and a digital-data communications link with the remote interrogator units, and UHF equipment for voice communications with the aircraft.

The CCS consists of computers, associated peripheral equipment (e.g., magnetic tapes, operator consoles), and signal processing and datalink equipment for communications with the ADDS and the TIS master station(s). The CCS computes aircraft positions, velocities, accelerations, attitudes, and angular rates by processing the range measurements from the TIS. The CCS processes aircraft weapons data to initiate weapons

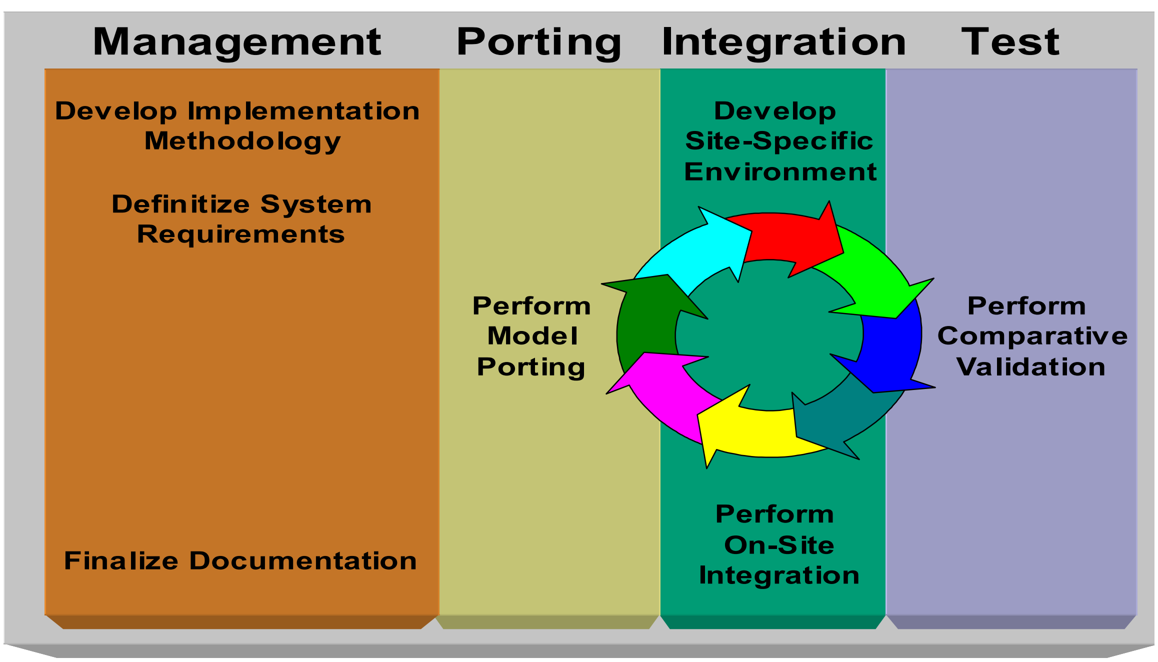

Figure 2. Activities

simulations and to supplement internal system data. For certain ranges, the CCS also provides processing for electronic warfare (EW) training capability by allowing incorporation of real threat simulators and computer generated threat simulators into the system and by managing an integrated air defense system and initiating, controlling, and monitoring EW simulations. All weapons and EW simulations are computed within the CCS; all aircraft tracking data, weapons trajectory data, EW and air defense system status data, and results of mission activities are transmitted to the ADDS in real time. The System Operator Console (SOC) provides the man-machine interface (MMI) between the system operator and the CCS. The SOC is used to enter, change, and delete mission data; create and maintain mission data files; and provide initialization data for operation of the CCS.

The ADDS is the next-generation display subsystem within ACTTS/TACTS. This subsystem monitors, acquires, and processes mission data from the CCS and displays the information in near real-time. The ADDS obtains mission audio from the UHF radio rack and broadcasts time-synchronized mission audio in real-time for the debriefing operator, time-correlated with graphic and alphanumeric display information. Like the SOC, the ADDS may also be used to enter, change, and delete mission data; create and maintain mission data files; and provide initialization data for operation of the CCS. The ADDS interfaces with the existing CCS from either a collocated position or a remote position. Data exchanged between the CCS and a remotely located ADDS is accomplished via a secure link.

INTEGRATION METHODOLOGY

Maintaining the validity of the RTSAM models received from DIA/MSIC was fundamental to the development of any RTSAM integration methodology. Another primary objective was to insure that current capabilities of the ACTTS/TACTS system would not be adversely affected by the integration. An initial methodology was developed using high-level (Level 1) system requirements and systems documentation. This methodology, which was documented in the form of a draft Concept of Operations (CONOPS), is described over the next several paragraphs.

It was determined that the best method to facilitate unobtrusive integration of the RTSAM models was to host them on independent computer platform. The breadth of functionality and the associated complexities of the CCS software was the primary driver for the decision to use an independent platform. The use of the independent platform also facilitates development and preliminary test activities. Based largely on the ongoing migration to the operating system by other RISPO programs, Windows NT was established as a goal.

This independence from the CCS via the use of an independent platform also provides additional benefits. Due to the complexities and scope of the CCS software, the process of generating and testing new CCS software builds often takes more than a year to complete. As the RTSAM models will not be integrated into the CCS code, upgrades can be performed quickly and easily. The independence also eliminates risk associated with certain site-specific aspects of the CCS logic. Finally, the use of an independent platform provides for increased portability of the RTSAM capability to for enhancement of other ACTTS/TACTS locations.

While the isolation provides definite benefits, it also isolates the RTSAM models from the basic information necessary for their operation. An alternative mechanism for obtaining and providing initial conditions and real-time targeting information, as well as a mission event data summary, would therefore have to be developed. It quickly became obvious that the large majority of the information required to execute the RTSAM models was being relayed by the CCS to the ADDS for support of real-time mission visualization. Initiation of RTSAM execution was proposed as a “mad dog” mode in which any entities crossing within the boundary launch zone (BLZ) would be treated as hostile and targeted. This capability, along with other support functions that are normally provided by the CCS, would be developed as “middleware”. This approach is illustrated in Figure 3.

While hardware independence can be achieved simply by hosting the software on a separate platform, the degree to which “true” software independence can be achieved via the proposed implementation remains a significant issue. Should modification of the ADDS software be required to support the planned implementation (therein creating a new ADDS baseline to support the performance augmentation), the proposed approach will have to be re-examined with regard to ACTTS/TACTS configuration management processes and RISPO program objectives.

Successful execution of the methodology will be dependent upon the integration site ultimately

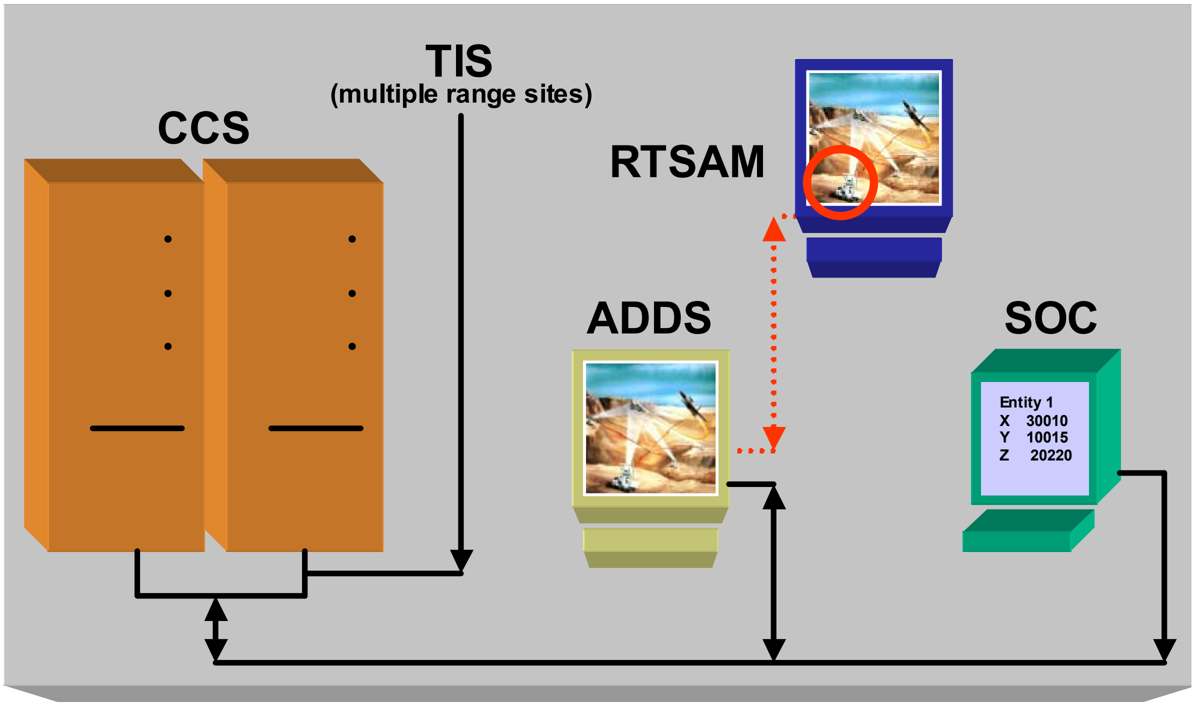

Figure 3. Equipment Diagram Showing Incorporation of RTSAM Host Platform

selected. While multiple possibilities for integration existed, two primary candidates were investigated: Tyndall AFB in Panama City, FL, and Gulfport Combat Readiness Training Center (Gulfport CRTC) in Gulfport, MS. Both locations are easily accessible to the RISPO (less than a half day's drive), enhancing team scheduling flexibility and cost constraint. Each candidate possessed specific advantages and disadvantages.

Integration at Tyndall AFB would capitalize on recent modernization of the Tyndall ACTTS infrastructure. Selection of Tyndall also aligns with the current CAF F-22 bed-down plan and Air Education and Training Command (AETC) stand-up of the F-22 Formal Training Unit (FTU). However, squadrons at Tyndall and nearby Eglin AFB utilize the Tyndall ACTTS heavily for training missions, introducing the distinct possibility of scheduling issues. The Tyndall range space, which is completely contained within the Gulf of Mexico, also limits the natural growth path in which the RTSAM models could be utilized to control existing ground-based threat emitters.

While Gulfport CRTC does not provide the direct advantage of synergism with the F-22 training program, there were other distinct advantages associated with its candidacy. Unlike Tyndall, Gulfport CRTC has airspace that encompasses both water and land, with several resident ground-based threat emitters in place. As an Air National Guard site, Gulfport CRTC is not routinely subjected to a high degree of aircrew training traffic, with direct support of most training missions accomplished within half a normal workday. This degree of range asset availability makes Gulfport CRTC an ideal location for concept exploration.

Although the allure of the F-22 synergism was highly coveted, the overall advantages resulted in the selection of Gulfport CRTC as the site for initial integration of the RTSAM models.

DEFINITIZE SYSTEM REQUIREMENTS

While the Level 1 Requirements are sufficient to develop the initial methodology, clarification of certain system requirements will be necessary to facilitate design decisions. Pertinent issues include the total number of instantaneous SAMs present within the environment, number of simultaneous SAM engagements (target tracks and interceptor fly outs), missile refresh rate, and computer processor requirements regarding memory and throughput to support the intended operations.

Subject Matter Experts (SMEs) at DIA/MSIC and HQ ACC will be consulted to determine allowable total number of instantaneous SAMs within the environment and number of simultaneous engagements. The SMEs will provide assistance with regard to representative capabilities and employment and operational fielding guidelines for the threats of interest. Personnel at Gulfport CRTC will also consulted to obtain the specific training requirements of their users. ACTTS/TACTS system capabilities were reviewed to determine existing bounds on support capability. Finally, the RTSAM models will be reviewed to determine specific bounds on capabilities. The RTSAM system was originally designed to support a minimum of 15 simultaneous site players and a minimum of 5 simultaneous interceptor players. The term site player refers to a SAM battery that may include the following subcomponents: target track radar (TTR), missile track radar (MTR), target illumination radar (TIR), identification friend or foe (IFF) transponder, and weapon controller with a fire control computer. The term interceptor player refers to the weapon launched by the SAM battery. The requirements governing this RTSAM integration effort will reflect a composite of the operational guidelines and the specific training requirements of the Gulfport CRTC users.

A nominal amount of time is required to re-arm a SAM battery following exhaustion of weaponry. "Missile Refresh Rate" will serve as a middleware parameter to mimic this delay in firing capability. Based on Gulfport CRTC concept of operations associated with the potential incorporation of ground-based emitters with RTSAM models, the value of missile refresh rate will be set artificially low to facilitate interaction with an increased number of participants during the mission time.

PERFORM MODEL PORTING

The RTSAM models will be obtained from DIA/MSIC for porting to the new platform. The models of the SA-10 and SA-20 systems (systems which possess very similar characteristics) each consist of a site player and an intercept player. The site player includes a Missile Track Radar (MTR) that functionally simulates mode logic and tracks the missile allocated to the engagement after an initial capture delay. The interceptor player includes a propulsion system, flight control systems and aerodynamic characteristics, autopilot system, and a missile seeker. The missile seeker simulates the detection and tracking performance of the missile seeker for the particular SAM system and missile variant using target radar cross section data provided as input.

The RTSAM system was originally designed for operation in the IRIX 6.5 OS executing on an SGI R10K processor hosted on an SGI Origin 2000 platform with 2 Gigabytes of RAM. As mentioned previously, the host platform will utilize the Windows NT OS.

The total number of expected RTSAM models to be integrated into the ACTTS/TACTS system will dictate memory requirements of the host platform. Software drivers used within the Lockheed Martin Aeronautical Systems (LMAS) ACS will be used in conjunction with additional software tools to verify the ability of the RTSAM models to execute to completion on the new platform.

DEVELOP SITE-SPECIFIC ENVIRONMENT

A digital testbed model of the site-specific environment will be created to facilitate the eventual on-site integration of the RTSAM models. Site-specific information will be obtained to insure compliance with existing ACTTS/TACTS system architecture and I/O considerations (e.g., content, timing). The controlled environment will serve as the primary test instrument prior to on-site integration efforts. The RTSAM system utilizes a WGS84 Earth Model. Site Players are capable of being located on terrain at any latitude, longitude and altitude location on the earth. Players within the RTSAM system are designed to provide a state report to the architecture at the end of every 50 millisecond (+/- 100 microseconds) frame. This state reports includes the data elements shown in Figure 4. A time stamp incremented from an initial reference of zero at the start of the simulation is also provided within the state report [3].

Latitude	**Longitude**
Mach	**Altitude**
Roll	**Roll Rate**
Pitch	**Pitch Rate**
Heading	**Heading Rate**
Velocity*	**Acceleration***

North, East, Down (NED) Components

Figure 4. RTSAM State Report Data Elements

PERFORM ON-SITE INTEGRATION

Following successful execution within the controlled environment, the RTSAM models will be integrated into the ACTTS/TACTS architecture at the selected site. This on-site integration will be performed in a manner not to interfere with training of Gulfport CRTC users and any required maintenance of the Gulfport CRTC ACTTS/TACTS system. The current schedule calls for at least one beta integration to be performed in order to evaluate I/O compliance and to collect data for comparison with the digital testbed prior to final integration.

PERFORM COMPARATIVE VALIDATION

As mentioned in a previous section, initial validation of the RTSAM models will be performed under the cognizance of DIA/MSIC. Following on-site integration at Gulfport CRTC, comparative validation will be performed using this initial validation effort as a baseline. Test plans that duplicate (as closely as possible) the initial conditions and mission construct of the initial validation effort will be developed, executed, and documented.

FINALIZE DOCUMENTATION

Documentation will be performed throughout the normal course of the effort. Upon completion of all efforts, the documentation will be reviewed and finalized for formal submittal.

SUMMARY

This effort attempts to capitalize upon the synergism that exists within the requirements of independent programs being conducted by the test and training communities. It is hoped that the products, the "lessons learned", and the degree of success achieved by this effort will serve as a benchmark for members of the respective communities that wish to pursue such ventures in the future.

POSTSCRIPT

Uncertainty regarding future operations and maintenance (O&M) support of the RTSAM models has recently become a significant issue for the CROSSBOW effort. In addition, funding concerns have necessitated the postponement of the ACTTS/TACTS effort until Government Fiscal Year 2002. An alternative approach that takes advantage of the standard JMASS architecture and missile flyout models is currently being explored in the interim.

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