

PHASE 1
VERIFICATION AND VALIDATION REPORT
FOR THE
END-TO-END TEST

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20000822 086

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ARI 00-11- 3732

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1.0 Scope

This report provides the results of the verification and validation (V&V) tasks performed during Phase 1 of the Joint Advanced Distributed Simulation (JADS) End-To-End (ETE) Test.

1.1 Purpose

This report details the results of executing the V&V requirements listed within the ETE Test Activity Plan, Appendix C, Verification and Validation Plan for the ETE Test.

1.2 Verification and Validation Tasks

The V&V tasks that were performed during or prior to Phase 1 are described in the ETE Test Activity Plan, Appendix C, Verification and Validation Plan for the End-To-End (ETE) Test.

1.3 Verification and Validation Process Models

Within this report, reference is made to steps enumerated within the Distributed Interactive Simulation (DIS) Nine Step Process Model. This model is shown below as Figure 1.

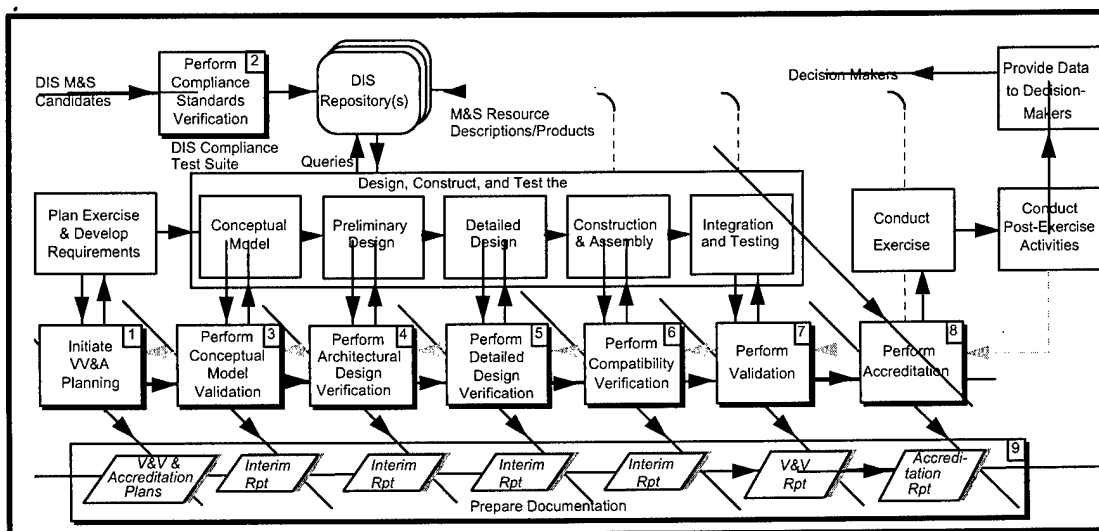


Figure 1. DIS Nine Step VV&A Process Model

The process model and its accompanying *Recommended Practice for Distributed Interactive Simulation -- Verification, Validation, and Accreditation (Draft-4 November 1996)* form the basis for the verification, validation and accreditation of the ETE Test synthetic environment (SE).

The DIS Nine Step Process Model was developed with a conventional, short-lived, DIS exercise in mind, as opposed to a test of a major system, and presupposes a full complement of funds and personnel available at the beginning of the exercise development. This disparity was brought to the attention of the developers of the DIS Nine Step Process Model, and the conclusion was reached that since the model was recommended and intended for tailoring to the needs of the user, the model would continue to be tied to the DIS exercise development and construction process contained within Institute of Electrical and Electronics Engineers (IEEE) Standard 1278.3.

If one tailors the DIS Nine Step Process Model to the joint test process, then the process model would appear as shown in Figure 2.

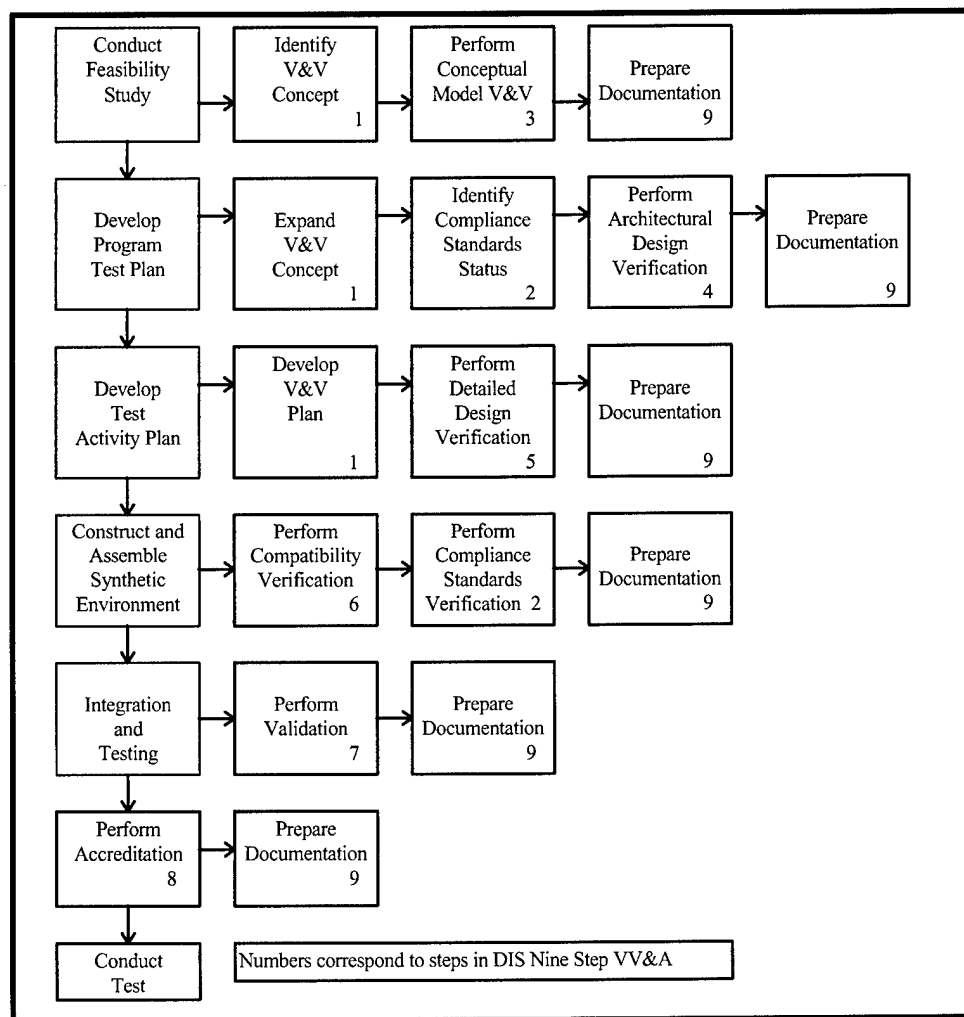


Figure 2. JADS ETE Test Process Model

In the JADS ETE Test Process Model, test events, which consist of the planning, construction and assembling of the SE, integration and testing of the SE, accreditation of the SE, and conduct

of the test all proceed on the left side from top to bottom. The V&V events, to include documentation, proceed to the right for each test event.

2. Applicable Documents

2.1 Documents

ETE Test Activity Plan, Appendix C, Verification and Validation Plan for the End-To-End (ETE) Test

Department of Defense Verification, Validation and Accreditation (VV&A) Recommended Practices Guide, November 1996

Recommended Practice for Distributed Interactive Simulation -- Verification, Validation, and Accreditation, 4 November 1996

Joint Advanced Distributed Simulation Joint Test and Evaluation Program Test Plan (PTP), February 1996

3. Verification and Validation Tools

The following software was used in the ETE Phase 1 V&V:

JADS Toolbox

JADS Logger

U.S. Army Simulation, Training and Instrumentation Command (STRICOM) Logger

POWERSIM™ Version 2.02, POWERSIM AS, Norway

4. Verification Tasks

This section of the Phase 1 V & V results states the verification requirements and describes the results of performing the verification steps as indicated in ETE Test Activity Plan, Appendix C, Verification and Validation Plan for the End-To-End (ETE) Test, Figure 2 JADS ETE Test Nine Step Process Model.

4.1 Perform Compliance Standards Verification (Step 2)

Initial compliance standards verification was performed during the development of the program test plan. At this time the models and simulations identified for use in the ETE SE were verified by reviewing simulation descriptions as meeting DIS compliance standards to the extent required.

During Phase 1, visits were made to each site using DIS-compliant simulations (Janus and Tactical Army Fire Support Model [TAFSM]) and prior exercises were reviewed to verify that the simulations were DIS compliant. Additionally, numerous Janus simulation exercises were conducted for the purpose of testing the Virtual Surveillance Target Attack Radar Simulation (VSTARS). The protocol data units (PDUs) broadcast by Janus and TAFSM during these simulation exercises were analyzed using the JADS Toolbox. All PDUs were found to be compliant with DIS standards as modified by the ETE Test.

The DIS standard requires that for an entity state PDU (ESPDU), the "... timestamp shall be specified using a 32-bit unsigned integer representing units of time passed since the beginning of the current hour. The least significant bit shall indicate whether the timestamp is absolute or relative." Because the ETE Test vignettes used in Janus involve nearly ten thousand entities and run for nearly seven hours, it was necessary to modify the standard and represent time as a 32-bit unsigned integer representing milliseconds since the beginning of the vignette (relative timestamp). This allows the tester to trace an ESPDU back to a discrete event that occurred within the Janus vignette. This is a common practice in most DIS SE that exist for periods greater than one hour.

TAFSM also uses a relative timestamp in the PDUs that it generates. Within TAFSM, the timestamp represents milliseconds since midnight of the day of the test. This method is the same as that used by the JADS logger and allows time tracking of the PDU throughout the ETE Test SE.

4.2 Perform Conceptual Model Verification (Step 3)

The conceptual model verification was performed during the development of the feasibility study. At this time, several conceptual models were verified by inspection and one was chosen for further development into the ETE Test SE.

The conceptual models developed for the ETE Test SE consisted of a series of as yet undefined simulation nodes that required inputs that would be used to generate outputs. The outputs of one or more simulation nodes would then become the inputs for another simulation node in the SE. The conceptual model developed for the ETE Test SE is represented by Figure 3.

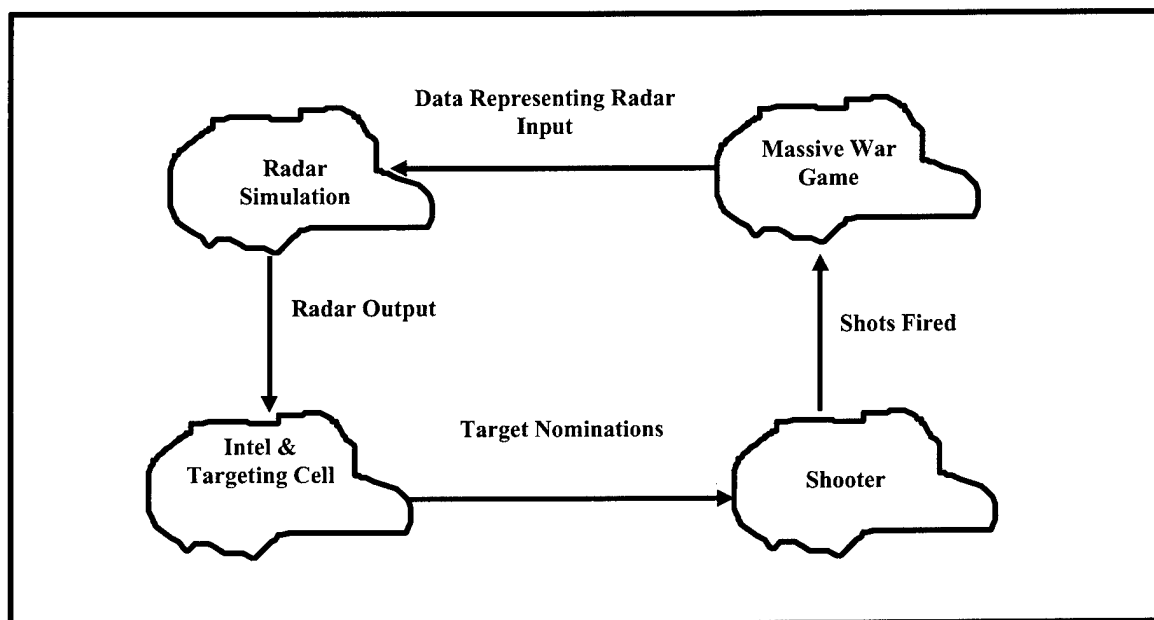


Figure 3. ETE Test SE Conceptual Model.

As can be seen from the figure, this simple conceptual model of the ETE Test SE calls for a source of information about potential targets (massive war game) that would be provided to a radar simulation representing the radar onboard the Joint Surveillance Target Attack Radar System (Joint STARS) E-8C aircraft. This radar simulation would provide radar output to an intelligence gathering, analysis, and targeting cell that would then use the radar output to nominate targets for engagement by the shooter within the SE. The shooter would then engage the nominated targets by interacting with the massive war game. The massive war game would determine the effect of the shots fired and would in turn report changes in target status to the radar simulation completing the ETE Test cycle.

4.3 Perform Architectural Design Verification (Step 4)

The architectural design verification was performed during the development of the PTP. It consisted of a document review, the development of a preliminary model of the SE, an allocation of functions and capabilities to the nodes of the SE, operational requirements mapping, a determination of interface requirements and database requirements, and initial personnel and test requirements.

4.3.1 Preliminary Model of End-to-End Synthetic Environment

The preliminary model of the ETE Test SE, Figure 3-15 in the Joint Advanced Distributed Simulation Joint Test and Evaluation Program Test Plan, February 1996, is shown here as Figure 4.

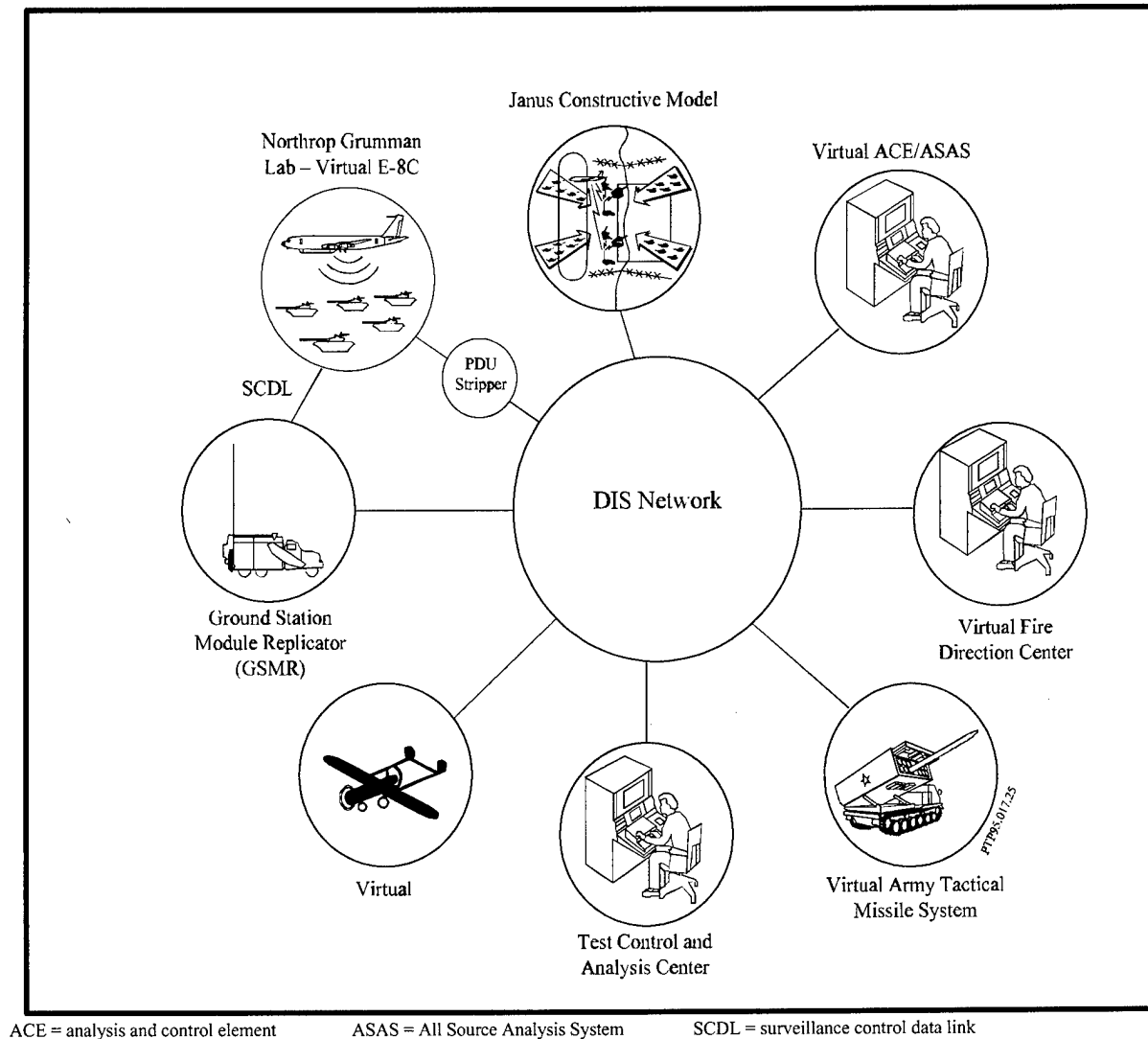


Figure 4. Preliminary Model of the ETE Test SE

4.3.2 Allocation of Functions

The allocation of functions for the preliminary model of ETE Test SE is shown in Table 1.

Table 1. Allocation of Functions & Capabilities for the Preliminary Model of ETE Test SE

NODE	FUNCTION	CAPABILITY
Virtual E-8C	Provides radar reports to SE	Receives ESPDUs and provides moving target indicator (MTI) radar (SAR) radar reports to GSM via the SCDL.
Ground Station Module (GSM)	Provides target information to analysis and control element (ACE)/All Source Analysis System (ASAS)	Receives MTI and SAR radar reports via the SCDL and provides spot reports to ACE/ASAS.
Virtual Unmanned Aerial Vehicle (UAV)	Provides real-time visual imagery of battlefield to GSM	Receives ESPDUs and provides visual imagery to GSM
Test Control and Analysis Center	Controls test and conducts both real-time and post-test analysis of data	Receives and logs all PDU and message traffic, except for SCDL.
Virtual Army Tactical Missile System (ATACMS)	Fires virtual ATACMS missiles into Janus	Receives fire missions from Virtual Fire Direction Center and fires ATACMS missile at designated target.
Virtual Fire Direction Center	Issues fire missions to Virtual ATACMS	Receives target nominations from ACE/ASAS and issues fire missions to virtual ATACMS
Virtual ACE/ASAS	Analyzes available intelligence and nominates targets for engagement	Receives target information from GSM and imagery from UAV. Nominates targets based on analysis of available intelligence.
Janus Constructive Model	Massive war game of at least 5000 entities.	Executes preexisting scenario with operator interaction; determines effects of ATACMS hits; and broadcasts ESPDUs reflecting status of each entity within the war game.

4.3.3 Operational Requirements Mapping

The operational requirements mapping was performed during the development of the PTP and is in paragraph 3.4 of the Joint Advanced Distributed Simulation Joint Test and Evaluation Program Test Plan, February 1996. An example is shown below.

JADS Joint Test Force

- Overall responsibility for the planning, execution, analysis, and reporting of the test.
- Develops advanced distributed simulation (ADS) measures and related events.
- Analyzes and evaluates ADS measures.
- Reports interim and final results to the Office of the Secretary of Defense (OSD).
- Develops the Phase 2 test plan.
- Develops V&V plan for ETE Phase 2.
- Establishes necessary communication links with test participants.
- Activates ETE Test DIS network.
- Develops necessary scenarios for ETE Test Phase 2.

4.3.4 Determination of Interface Requirements

The interface and database requirements for the preliminary model of the ETE Test SE are shown in Table 2.

Table 2. Interface & Database Requirements for the Preliminary Model of ETE Test SE

NODE	INTERFACE REQUIREMENTS	DATABASE REQUIREMENTS
Virtual E-8C	DIS network interface unit, surveillance control data link (SCDL) 1553 interface unit	Enumeration database System databases
Ground Station Module (GSM)	SCDL 1553 interface unit, system communication interfaces	System databases
Virtual unmanned aerial vehicle (UAV)	DIS network interface unit, system communication interfaces	Enumeration database Terrain databases
Test Control and Analysis Center	DIS network interface unit	Enumeration database Terrain database
Virtual Army Tactical Missile System (ATACMS)	DIS network interface unit	Enumeration database Terrain databases System databases
Virtual Fire Direction Center	DIS network interface unit	System databases
Virtual analysis and control element (ACE)/All Source Analysis System (ASAS)	System communication interfaces	System databases

Janus Constructive Model	DIS network interface unit	Terrain databases Force databases Enumeration databases Scenarios
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4.3.5 Initial Personnel and Test Requirements

Initial personnel and test requirements are in paragraph 3.4 of the Joint Advanced Distributed Simulation Joint Test and Evaluation Program Test Plan, February 1996.

4.4 Perform Detailed Design Verification (Step 5)

The initial detailed design verification was performed by the ETE Test V&V team during Phase 1 of the ETE Test. The V&V team:

- a) reviewed model and simulation (M&S) component documentation and, if necessary, source code to determine component ability to perform their assigned functions;
- b) executed key algorithms to ensure they functioned appropriately to address the exercise requirements;
- c) assessed the logic of the proposed interconnections of the components by evaluating the proposed interchange of PDUs; and,
- d) analyzed the exercise design for its rigor.

In addition, members of the V&V team evaluated the appropriateness and sufficiency of the input data selected for use in the exercise.

This activity involved five major tasks: evaluate detailed design, evaluate interface design, verify data and databases, evaluate V&V test plans, and evaluate training requirements.

4.4.1 Evaluate Detailed Design

This task involves determining if the design is sufficient to ensure

- a) the individual M&S components are capable of representing the exercise phenomenology at appropriate levels of resolution; and
- b) the underlying network assets can support the exchange data among the components at the necessary levels of fidelity.

This task was accomplished in the following manner:

- a) Acceptance testing of M&S components to ensure they are capable of representing the exercise phenomenology at appropriate levels of resolution.
- b) Characterization of underlying network assets to determine if they can support the exchange of data among the components at the necessary levels of fidelity.

- c) Simulation of elements of the detailed design to determine their functionality using POWERSIM™ Version 2.02.

4.4.1.1 Acceptance Testing

Acceptance testing was conducted on VSTARS, Advanced Radar Imaging Emulation System (ARIES), and the JADS ground data terminal 1553 bus interface unit. Results of the acceptance tests may be found at

- a) Appendix A, JADS Ground Data Terminal 1553 Bus Interface Unit Acceptance Test
- b) Appendix B, Advanced Radar Imaging Emulation System (ARIES) Acceptance Test
- c) Appendix C, VSTARS Acceptance Test

4.4.1.2 Characterization of Network Assets

Characterization of the ETE Test network assets was conducted by the JADS Network and Engineering (N&E) team. Results of the characterizations may be found at

- a) Appendix D, Characterization Reports From JADS JTF/ETE (N&E)
- b) Appendix E, LWX and Cisco Router Performance Test Report

4.4.1.3 Simulation Using POWERSIM™

Early in Phase 1, prior to the establishment of the ETE Test network, a simulation was built using POWERSIM™ to determine if the detailed design could support the desired SE. A model of the portion of the network that would handle ESPDUs was developed and the traffic over the network was studied using various values and distributions of latency, PDU dropout, etc.

In addition to changing network variables, such as latency, the load on the network could be increased by varying the number of entities, the number of moving entities, and other similar variables. Finally, the DIS parameters, such as heartbeat rate, could be varied at will. This resulted in a very robust simulation.

This simulation was able to verify that the detailed design was capable of supporting a wide range of network conditions and should be able to support the ETE Test SE. In addition, the simulation provided design information to the engineers who were developing the VSTARS network interface unit.

Some of the POWERSIM™ output is included as Appendix F, POWERSIM™.

4.4.2 Evaluate Interface Design

This task was performed during the acceptance testing of the components of the SE and evaluated the ability of the individual M&S components to interoperate with each other and with the network by

- a) determining that interfaces among components and interfaces with the synthetic environment are adequate and sufficient to allow consistency in the level of details, data fidelity, and data sources, and sufficient modes of operation;
- b) ensuring that user interfaces for input and output can pass information to accomplish efficient scenario construction, component execution, network management, and report generation, and
- c) evaluating the impact of network factors such as latency produced, network loading, and filtering requirements.

Appendices A through E contain the results of the acceptance tests and network investigations.

4.4.3 Verify Data and Databases

There are two primary sets of simulation data used within the ETE Test. They are terrain data used by VSTARS, Janus, and TAFSM, and weapon system performance data used by Janus and TAFSM.

Due to the unclassified nature of the test, it was decided that the unclassified system performance data provided for use within Janus and TAFSM would be used for the ETE Test. This is possible because the moving target indicator (MTI) radar simulation of VSTARS detects targets based upon their velocity. The range of velocities represented by the unclassified system performance data is the same as would be expected from the actual target during normal operations.

Unfortunately, the terrain data available for use within the ETE Test were unusable because of their low fidelity and resolution. It was therefore decided to construct our own terrain databases. These terrain databases will be verified during Phase 2.

4.4.4 Evaluate V&V Test Plans

During Phase 1, the V&V test plan, ETE Test Activity Plan, Appendix C, Verification and Validation Plan for the End-To-End (ETE) Test, was published and reviewed by the JADS ETE Test accreditation board.

4.4.5 Evaluate Training Requirements

An evaluation of training requirements revealed that all of the real systems used within the ETE Test are fielded systems with operators who have attended the appropriate training schools. No new equipment training is required pursuant to the ETE Test. It was observed, however, that many of the operators had either not been well trained during their initial entry courses or had forgotten certain skills from lack of use or lack of training opportunities. As an example, ground station module (GSM) operators receive no training in the use of Joint STARS synthetic aperture radar (SAR) images during their initial entry course.

This situation requires that during the functionality and integration tests and risk reduction tests scheduled for Phase 2, the operators of the fielded systems will need to be retrained on the use of their equipment.

The existing simulations, Janus and TAFSM, require minimal training of their operators on newly added features. This training was conducted as new features were added during Phase 1.

VSTARS utilizes the standard operator interface used by Joint STARS. As such, it requires no new equipment training of the operators. Because it is an emulation of the radar subsystem used by Joint STARS, it may be used for refresher training as mentioned above.

5. Validation Tasks

5.1 Perform Conceptual Model Validation (Step 3)

The JADS ETE Test conceptual model validation was performed during the conduct of the feasibility study. During this period, discussions were held with the Military Intelligence School, Fort Huachucha, Arizona; the Field Artillery School, Fort Sill, Oklahoma; Joint STARS Program Office and Northrop Grumman, Melbourne, Florida; and the U.S. Army Training and Doctrine Command (TRADOC) Analysis Center, White Sands Missile Range, New Mexico, as to the validity of the conceptual model.

All agreed that doctrinally and functionally, the conceptual model represented the real-life target detection, target identification, target assignment, target engagement, battle damage assessment loop that the ETE Test desired to replicate. The conceptual model considered during this validation step is shown in Figure 1.

6. Conclusion

This verification and validation report covers the first five steps of the exercise VV&A process as referred to in the *Recommended Practice for Distributed Interactive Simulation--Verification, Validation, and Accreditation*, 4 November 1996. This process, commonly referred to as the DIS Nine Step VV&A Process, was developed by the DIS Verification, Validation and Accreditation subgroup of the Workshops on Standards for the Interoperability of Distributed Simulations, of which the author of this report is a member.

No final conclusions may be inferred from this report as to the authenticity and validity of the ETE Test synthetic environment. What may be determined is that these early V&V steps provided confidence in the design of the environment and were instrumental in developing specifications and requirements for the continued development of the environment. Additionally, problems were identified early in the program, as a result of these V&V efforts. This enabled the ETE Test team to react proactively manner throughout the development of the ETE Test synthetic environment.

Additionally, this report helps to authenticate the DIS Nine Step VV&A Process as being a feasible process that may be adapted to support the V&V of a DIS synthetic test environment involving live elements, virtual simulations, and constructive simulations.

Appendix A

JADS Ground Data Terminal 1553 Bus Interface Unit Acceptance Test

JADS Bus Interface Unit (BIU) Qualification Test Procedure

Three test configurations are identified herein to support the test levels and definitions described by the previously submitted software test plan (STP). This procedure describes each test configuration, tests conducted for that configuration, and a brief procedure for each test. All test definitions from the software test plan are included within this procedure; however, they will be executed in accordance with the test configuration order presented below.

Test Configuration I

Software emulation of common ground station (CGS) running on JADS BIU workstation

JADS BIU software running on JADS BIU workstation

Software emulation of T-1 link running on "Kong" workstation

Triax termination on primary 1553 connector which links the CGS emulation software to the JADS BIU software via 1553 bus.

Ethernet link between JADS BIU and "Kong" network

When each of the three software components have been initiated, the CGS emulator will send control messages and uplink messages (rate = 0.1 hertz [Hz]) to the BIU over the 1553 bus, automatically triggering the ground data terminal (GDT) status transitions. The T-1 link emulator software, upon receiving the first uplink message from the BIU over the Ethernet link, will respond by sending downlink messages (rate = 80 Hz) and aircraft location messages (rate = 1 Hz). When the JADS BIU software transitions to the downlink enabled mode, it will pass the messages through the 1553 bus where they will be detected by the CGS emulator software. Results of the tests will be verified by examination of log files generated as the above scenario is executed.

Test Configuration I Coverage

a) GDT Initial Status (STP Paragraph 4.1.4.1)

Verify control word portion of initial GDT status report from CGS emulator log file

b) GDT Initial Status Message Blocking (STP Paragraph 4.1.4.2)

Examine JADS BIU log file to verify that uplink messages are counted only when uplink is enabled, and that downlink messages are counted only when downlink is enabled.

c) GDT Initial Status Transition (STP Paragraph 4.1.4.3)

Examine JADS BIU log file to verify that uplink Enabled and downlink enabled mode transitions take place.

d) GDT Uplink Messages (STP Paragraph 4.1.4.4)

Examine T-1 emulator log file to verify the indication of test uplink messages passed through the JADS BIU and transmitted via Ethernet to the “Kong” workstation.

e) GDT Uplink Message Latency (STP Paragraph 4.1.4.5)

Examine JADS BIU log file to record maximum and average uplink latency values in milliseconds.

f) GDT Downlink Messages (STP Paragraph 4.1.4.6)

Examine JADS BIU log file to record maximum and average uplink latency values in milliseconds.

g) GDT Aircraft Location Messages (STP Paragraph 4.1.4.7)

Examine CGS emulator log files to verify the indication of aircraft location data updating the appropriate fields of the GDT status message.

Test Configuration I Results

All elements of test configuration I meet requirements.

Test Configuration II

CGS server 1553 connection to provide downlink data request

JADS BIU software running on JADS BIU workstation

Software emulation of T-1 link running on “Kong” workstation

Cable connection between primary 1553 connector which links the CGS server to the JADS BIU software via 1553 bus.

Ethernet link between JADS BIU and “Kong” network

Requests for downlink data are generated periodically (20 Hz) by the CGS server. The T-1 link software emulation generates aircraft location and downlink messages at a rate which is

comparable to that supported by the actual T-1 link maximum. Uplink messages will be generated from the CGS workstation console, and when the first message is passed through the JADS BIU to the T-1 emulation software, downlink and aircraft location message transmission will begin. Results of the tests will be verified by log files generated on the JADS BIU workstation.

Test Configuration II Coverage

a) GDT Downlink Latency (STP Paragraph 4.1.4.7)

Examine JADS BIU log file to record maximum and average downlink latency values in milliseconds.

b) GDT Traffic Capacity (STP Paragraph 4.1.4.9)

Examine JADS BIU log file to record maximum throughput rate in messages per second.

Test Configuration II Results

All elements of test configuration II meet requirements.

Test Configuration III

CGS Server 1553 connection to JADS BIU workstation

E8 aircraft simulator connection to JADS BIU workstation (T-1/ Integrated Digital Network Exchange [IDNX])

The workstation will require reconfiguration and reboot to incorporate new internet protocol (IP) address and port data, which are necessary to support its operational configuration.

Test Configuration III Coverage

a) GDT Initial Status (STP Paragraph 4.1.4.10)

Capture GDT status report at CGS console using bus monitor log facility.

b) GDT Initial Status Transition (STP Paragraph 4.1.4.11)

Use CGS manage links controls and periodic status displays on JADS BIU console to verify the status transitions.

c) GDT Aircraft Location Messages (STP Paragraph 4.1.4.14)

Use CGS workstation imagery window to display the simulated E - 8C flight path.

d) GDT Uplink Messages (STP Paragraph 4.1.4.12)

Generate radar service request (RSR) and freetext messages using CGS workstation and confirm receipt at Grumman facility.

e) GDT Downlink Messages (STP Paragraph 4.1.4.12)

Use CGS message alert facility to display freetext message originated from the simulated E - 8C; use imagery window to display moving target indicator (MTI) and synthetic aperture radar (SAR) imagery patterns.

Test Configuration III Results

a) GDT Uplink Messages (STP Paragraph 4.1.4.12)

Generate RSR and freetext messages using CGS workstation and confirm receipt at Grumman facility.

Capability not present on CGS workstation used for acceptance test. Requirement deferred until installation of BIU on light ground support module (LGSM) at Fort Hood.

b) GDT Downlink Messages (STP Paragraph 4.1.4.12)

Use CGS message alert facility to display freetext message originated from the simulated E - 8C; use imagery window to display MTI and SAR imagery patterns.

Image dropouts observed when displaying MTI and SAR imagery patterns. This is believed to be caused by too fast a data transmission rate when transmitting MTI and SAR imagery patterns. We will modify Virtual Surveillance Target Attack Radar System (VSTARS) surveillance control data link (SCDL) interface to make data transmission rate adjustable and tune data transmission rate during installation of BIU at Fort Hood.

Appendix B

Advanced Radar Imaging Emulation System (ARIES) Acceptance Test

Section 5 extracted from the *Final Report for the Advanced Radar Imaging Emulation System (AIRES) Program*.

5. Factory Acceptance Testing

A test suite of images has been established as the baseline regression and factory acceptance test for the ARIES product. Each ARIES requirement is mapped to at least one test image which demonstrates ARIES ability to support that requirement. Additional test cases are provided to validate system performance and accuracy.

5.1 Requirements versus Test Cases

Table 5.1-1 defines all ARIES requirements and maps each to a test case. The test cases are described in the table that follows. All test cases have been run and the images, FID (Feature Identification) maps, shadow maps, gain maps (based on geometry and reflectivity of the surface) and other output information examined to verify accuracy.

Table 5.1-1 ARIES Requirements

Req #	Test #	Requirements
100	1	ARIES will simulate a JSTARS SAR image in real-time on a DEC Alpha 600/533 workstation as specified in the Classified Appendix
110	2	ARIES shall implement an earth curvature corrected coordinate system.
120	3	ARIES shall simulate a fixed image size with dimensions of 2 km x 4 km.
130	3	ARIES shall simulate an image with constant resolution in range and azimuth.
140	4	ARIES shall simulate images in the slant plane.
150	4	ARIES shall generate a magnitude simulated image.
160	4	ARIES shall simulate leading edge effects.
170		ARIES shall simulate the effects of range layover.
190	2	ARIES shall simulate the effects of obscuration along the sensor line-of-sight.
200	4	ARIES shall simulate a single look capability.
210	4	ARIES shall simulate a focused Spot SAR.
220	4	ARIES shall simulate depression angles up to 12 degrees relative to horizon.
230	4	ARIES shall simulate a maximum squint angle of +/- 60 degrees off broadside.
240		ARIES shall simulate summer seasonal conditions.

250		ARIES shall simulate clear atmospheric conditions.
260	6	ARIES shall simulate calm wind conditions.
270	4	ARIES shall simulate SAR imagery in accordance with JSTARS sensor performance parameters.
280	4	ARIES shall simulate X-band.
290	4	ARIES shall simulate HH polarization.
300	3	ARIES shall simulate a single resolution in range and azimuth as specified in the classified appendix.
320	2	ARIES shall use an elevation database for simulating topographical effects within a simulated image.
325	8	ARIES shall support an elevation database which encompasses an area up to 512 km x 512 km.
330	4	ARIES shall use a feature database to locate natural and cultural features within a simulated image.
340	2	ARIES shall accept earth curvature corrected elevation data from the GFE database.
350	2	ARIES shall accept earth curvature corrected feature data from the GFE database.
360	4	ARIES shall accept point feature data.
370	4	ARIES shall accept linear feature data.
380	26	ARIES shall accept areal feature data.
390	n/a	ARIES shall incorporate effects of features and topography which lie outside of Area of Interest (AOI) that influence obscuration within the AOI.
420	8	Rocky flats (maximum boulder size of 1 foot)
430	9	Packed sand and gravel
440	4	Loose sand
450	10	Windblown dunes
460	11	Dry depressions with sandy bottoms
470	12	Wadis
480	13	Escarpments
490	14	Salt marshes
500	15	Salt flats
510	16	Flood Plains
520	4	Date palm orchards
530	17	Irrigated fields
540	4	Buildings
550	4	Cylindrical storage tanks
560	4	Oil wells
570	2	Above ground pipelines
580	18	Soil/sand/dirt berms referred to as revetments
590	19	Below ground sand/dirt trenches
600	4	Above ground concrete and dirt bunkers

610	19	Sand/dirt ditches
620	4	Paved roads
630	20	Unpaved roads
640	21	Loose dirt trails (less than 1 road width)
650	2	Railroad tracks
660	4	Airfields - composed of buildings and runways
670	4	Transmission towers - 4 sided pyramidal
680	4	Electric power lines
690	22	Dirt and concrete dikes and levees
700	23	Dirt and concrete walls and berms
710	19	Anti-tank ditches
720	2	Pipelines within trenches
730	24	Quarries
740	2	Chain link fences
750	2	Concertina fences
760	2	Barbed wire fences
770	2	Bridges
800	4	ARIES shall simulate moving targets.
810	4	ARIES shall simulate stationary targets.
830	4	Tanks, ie. T-72, T-72 w/plow, T-72 w/mine roller, T-54/55
840	4	Air Defense Systems, ie. Long Track Radar, MTLB, ZSU-23-4
850	4	Armored Personal Carrier, ie. BMP-1, BMP-2, MTLB
860	4	Artillery, i.e. 2S1, 2S3
870	4	Armored Cars, ie. BRDM w/machine guns, BRDM w/AT-5s, BTR-60, BTR w/120mm mortars.
880	4	Artillery, i.e. BM-21, BM-22, D-30, T-12
890	4	Support Trucks, i.e. UAZ-469, 5-Ton CAC, 5-ton fuel, 2 ½-ton cargo
900	4	MI-24
910	4	MI-8 Hip
920	4	HAVOC
930	4	ARIES shall support TEL targets.
940	b2.1	ARIES shall simulate SAR imagery in accordance with data provided through an interface with Northrop Grumman's RPSI as specified in the ARIES-RPSI Interface Control Document.
950	b2.1	All coordinates passed to ARIES through the RPSI shall be relative to a topocentric coordinate.
960	b2.1	Area of Interest Centroid (x,y,z) (m)
970	b2.1	Resolution (m)
980	b2.1	Wavelength (m)
990	b2.1	Dwell Time (s)
1000	b2.1	Azimuth extent (radians)
1010	b2.1	Range extent (m)
1020	b2.1	Sensor position (x,y,z) (m)
1030	b2.1	Sensor velocity vector (m/s)

- 1040 b2.1 Antenna orientation vector
- 1050 b2.1 Number of targets within image
- 1060 b2.1 For each target in the image area, Target category, ie. tank, truck, launcher
- 1070 b2.1 For each target in the image area, Target subcategory, ie. M-1, M-60
- 1080 b2.1 For each target in the image area, Target specifics
- 1090 b2.1 For each target in the image area, Target position centroid (x,y,z) (m)
- 1100 b2.1 For each target in the image area, Target velocity vector (m)
- 1110 b2.1 For each target in the image area, Target orientation vector
- 1120 For each target in the image area, target appearance
- 1170 b2.1 ARIES software shall execute on the Alpha 600 5/333 workstation.
- 1180 b2.1 LM shall have 1GB of RAM on the Alpha 600 5/333 dedicated to ARIES during simulation activity.
- 1190 b2.1 ARIES executable software and resident operating system shall have access to 100% of the processing resource CPU time on the Alpha 600 5/333 during simulation activity.
- 1200 1 ARIES software shall execute under OpenVMS, version 6.2 or later.
- 1210 b2.1 ARIES software shall be compatible with the RPSI environment.
- 1220 ARIES software shall return a pass status upon successful completion of image generation.
- 1230 b2.1 ARIES software shall return a fail status upon unsuccessful completion of image generation.
- 1260 b2.1 ARIES shall pass image data to the RPSI with 2000/R pixels in cross-range by 4000/R pixels in range where R is the resolution parameters in meters passed by the RPSI.
- 1300 b2.1 ARIES software shall accept a Ground Reference Coverage Area (GRCA) as input from the RPSI as specified in the ARIES - RPSI Interface Control Document.
- 1310 b2.1 ARIES shall simulate an image which is completely encompassed by the GRCA boundaries.

5.2 Test Cases Defined

Tables 5.2-1 defines the test cases and describes what each test case involves.

Table 5.2-1 Test Case Description

Test #	Title	Description
1	Alpha Execution	Run alpha test program on both the SUN and the alpha with default values to generate an image output file. Verify the image from the alpha matches the same image generated on the SUN. This image is generated using the small library, small DFAD and small GRCA.

- | | | |
|----|---|--|
| 2 | Terrain / Shadow /
Feature Verification | Output is the shadow map from 8 different angles of the same terrain. Print and align the maps to verify terrain matches in all. AOI is at 0, 0. Final image contains artificial features used for quality verification. These image contains a feature of known height in known terrain at known depression angles. Verify shadow length. |
| 3 | Resolution
Distortion | Compare with test #2 for different resolution in X and Y. |
| 4 | General Image
Quality | Generate airport scene and verify image quality of contained features. Print out feature maps and align to verify constant location of features. Image contains all target types and moving targets. |
| 5 | Terrain / Feature
Matching | Print the gain and the feature maps and overlay to verify match between the two. |
| 6 | Windy | Run only the first few images and compare the windy palm trees with the calm palm trees in test 4. |
| 7 | GRCA Test | Different sizes and shapes of GRCA's in different ARIES of the database. Verify features and terrain. |
| 8 | Coarse + Smooth
Textures + Stream +
Mnt. | Image shows the coarse texture contained within the smooth texture background. |
| 9 | Fine + Smooth
Textures | Image shows the fine texture contained within the smooth texture background. |
| 10 | Dunes + Smooth | Image shows an area of sand dunes within the smooth texture background. |
| 11 | Dry Depression | Sample image of feature and other missing items |
| 12 | Wadi | See test 11 |
| 13 | Escarments | Sample image of feature |
| 14 | Salt Marshes | Sample image of feature |
| 15 | Salt flats + Pipeline | Sample image of feature |
| 16 | Flood Plains | Sample image of feature |
| 17 | Irrigated fields | See test 11 |
| 18 | Soil/sand/dirt berms
referred to as
revetments | See test 11 |
| 19 | Below ground
sand/dirt trenches | See test 11 |
| 20 | Unpaved roads +
Ocean | Sample image of feature |
| 21 | Loose dirt trails
(less than 1 road
width) + Dry Lake | Sample image of feature |
| 22 | Dirt and concrete
dikes and levees | Also includes orchards, power plants, telephone poles and wires and a real bridge! |

- 23 Dirt and concrete walls and berms Sample image of feature
- 24 Quarries Sample image of feature
- 25 Divided Hiway Sample image of feature
- 26 Area Features This is a set of artificial area features designed to challenge the area feature routines. Print the FID maps and verify alignment.
- 27 Timing Run a set of images on sarsim using a complete but reduced library to assess actual timing.
- 28 Odd angles General test at odd angles, compare FID maps with those from test 4.
- 29 Linear Test pattern of linear objects.
- 30 Runways Dual runways
- 31 Orchards Orchard areas.

5.3 Real Time Processing Predictions

Table 5.3-1 illustrates the allocated and projected image processing times. The projected execution at NG was 32.7 seconds. The actual execution time for the same image was 24 seconds. Execution time will vary depending on image contents. During build 3 delivery at NG reliable execution times as high as 30 seconds were noted. This is all still below the projected time.

Table 5.3-1 Allocated and Projected Image Processing Times

CSC	Allocated	Timing Predictions		Actual Times			
	%	Target Host Times Required	Sun Ultra 1 Timing Allocation based on Build 2 benchmark	Actual Timings on Sun Ultra 1	Predicted vs Actual Timing Differences on Sun Ultra 1	Predicted Host Execution Times based on Build 2 benchmark	%
		20.00	22.14	48.70	90%	44.00	
Process RPSI Data	0.00%	0.00	0.00		0.00	0.00	0.00%
External Obscuration	5.00%	1.00	1.11		1.11	0.00	0.00%
Transform AOI	5.00%	1.00	1.11		1.11	0.00	0.00%
Generate Point Map	25.00%	5.00	5.53	8.00	-2.47	7.23	22.11%
3D to 2D Projection	15.00%	3.00	3.32	2.00	1.32	1.81	5.53%
Chip & Texture	15.00%	3.00	3.32	7.00	-3.68	6.32	19.34%
Final Image Proc.	35.00%	7.00	7.75	15.47	-7.72	13.98	42.75%
Image Output	0.00%	0.00	0.00	3.72	-3.72	3.36	10.28%
Totals	100.00%	20.00	22.14	36.19	-14.05	32.70	100.00%
Initialization				300.00		271.05	

Table 5.3-2 uses the measured execution times from the SUN scaled to the original image size of 1024 x 512 pixels. The projected execution time here is well within the time allotment when processing this size of image.

Table 5.3-2 Measured Execution Time from SAR

CSC	Allocated	Timing Predictions		Actual Times			
	%	Target Host Times Required	Sun Ultra 1 Timing Allocation based on Build 2 benchmark	Actual Timings on Sun Ultra 1	Predicted vs Actual Timing Differences on Sun Ultra 1	Predicted Host Execution Times based on Build 2 benchmark	%
		20.00	22.14	48.70	90%	44.00	
Process RPSI Data	0.00%	0.00	0.00		0.00	0.00	
External Obscuration	5.00%	1.00	1.11		1.11	0.00	
Transform AOI	5.00%	1.00	1.11		1.11	0.00	
Generate Point Map	25.00%	5.00	5.53	2.48	3.05	2.24	24.10%
3D to 2D Projection	15.00%	3.00	3.32	0.62	2.70	0.56	6.02%
Chip & Texture	15.00%	3.00	3.32	2.17	1.15	1.96	21.09%
Final Image Proc.	35.00%	7.00	7.75	3.87	3.88	3.49	37.58%
Image Output	0.00%	0.00	0.00	1.15	-1.15	1.04	11.21%
Totals	100.00%	20.00	22.14	10.29	11.85	9.30	100.00%
Initialization				300.00		271.05	

Appendix C
VSTARS Acceptance Test

PRELIMINARY PERFORMANCE ASSESSMENT REPORT
FOR PHASE I
VIRTUAL SURVEILLANCE TARGET ATTACK RADAR SYSTEM
(VSTARS)

CONTRACT NO.: F30602-96-C-0281
CDRL SEQUENCE NO.: A006

Prepared for:

USAF, AFMC
Rome Laboratory/PKRZ
26 Electronic Parkway
Rome, NY 13441-4514

Prepared by:

Northrop Grumman
Surveillance and Battle Management Systems
2000 NASA Blvd. West
Melbourne FL 32904-2322

G. Waldrop Technical Cognizance A.W. Robertson JADS IPT Lead R. Floto Systems Engineering IPT M. Addison Technical Integration Manager D. Johnston Software Quality Assurance	J. Lee Engineering Manager C. Liang Chief Engineer J. Newman System Test IPT Lead O. Vega Software IPT Lead
Date	Date
Date	Date
Date	Date
Date	Date

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1. INTRODUCTION

Purpose/Scope - The purpose of this report is to provide the test results obtained from the JADS Phase I Acceptance Test. The acceptance test for the Virtual Surveillance Target Attack Radar System (VSTARS) was conducted by test engineers in the presence of government representatives at the Northrop Grumman test facility located at Melbourne, FL. The purpose of the test was to operationally test VSTARS using two Alpha 600 computers and Joint STARS software to determine if all contractual requirements were satisfied.

The VSTARS Acceptance Test for JADS Phase I demonstrated the ability of VSTARS to provide simulated target data integrated with live target data detected by Joint STARS via the Radar Processor Simulator and Integrator (RPSI). The simulated target data was detected by a Moving Target Indicator (MTI) Simulation and a Synthetic Aperture Radar (SAR) simulation.

Testing was conducted on two Alpha 600 workstations in the JADS Laboratory at the Northrop Grumman ITF using the JDS03_108B0 build. The VSTARS ALPHA 600 workstations and the SGI workstation, the PDU Logger/Playback equipment, were interconnected on the Ethernet LAN" shown in Figure 0-1 as the "D1" connection.. Seven test points were included in the procedure. As run procedures are included in Appendix A. Five test points were successfully completed. One test failed two steps and will be re-tested during Phase II. The other test point failed as a result of a misinterpretation between Northrop Grumman and JADS Joint Task Force (JTF), and was corrected on the spot.

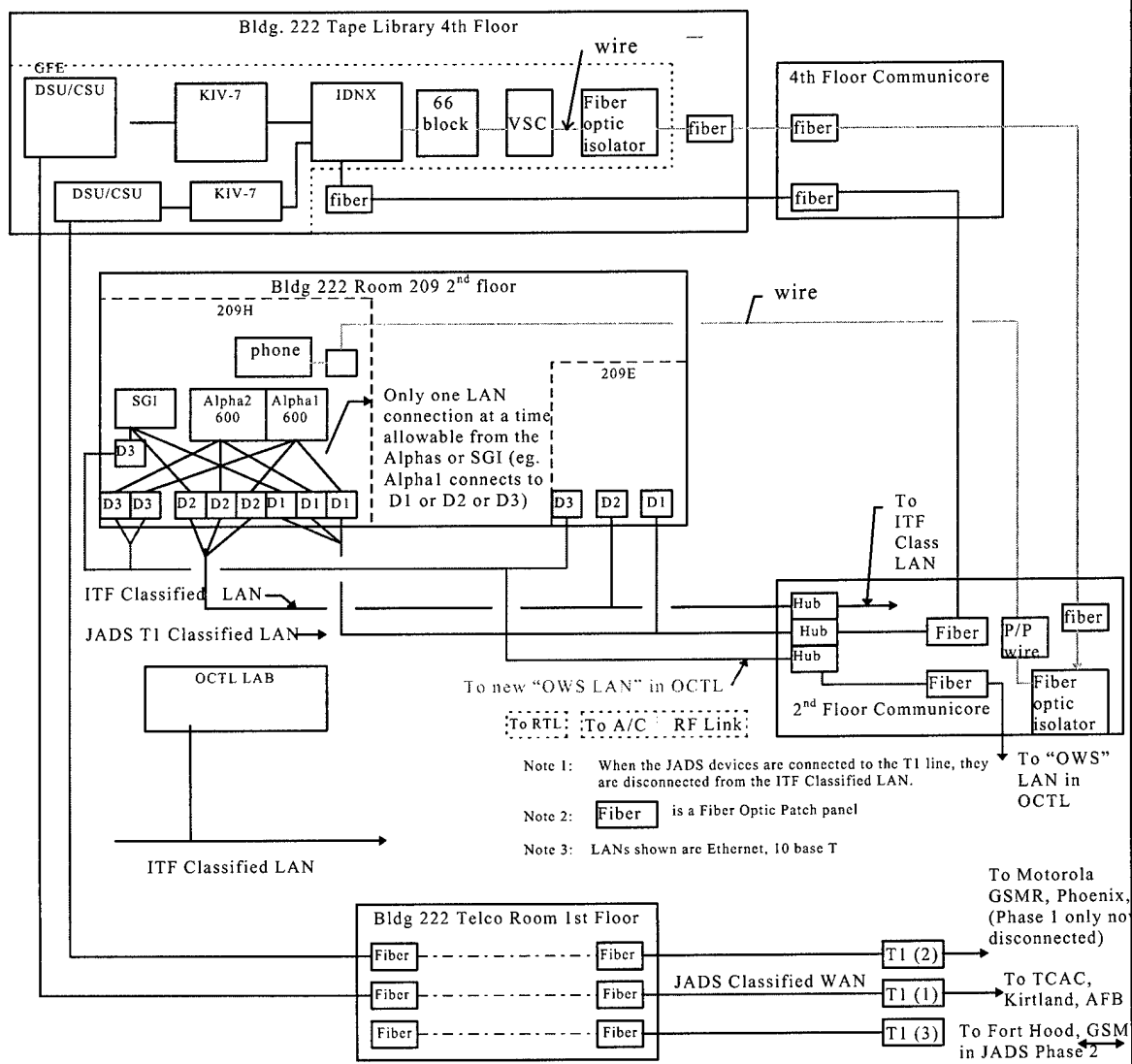


Figure 0-1 - JADS Communications Connections In Northrop Grumman ITF

2. TEST IDENTIFICATION

Preliminary Performance Assessment for Phase I of VSTARS Test Report, hereafter referred to as the Test Report, is submitted in response to Contract Data Requirements List (CDRL) item A006 under the Joint Advanced Distributed Simulation (JADS) Program Contract No. F30602-96-C-0281. Content and format are in accordance with the requirements of ANSI Z39.18 Paragraph 5.1.1, in conformance with the JADS Statement of Work (SOW).

This test report contains the results from the 12 November 1997 Preliminary Assessment Testing of VSTARS. The following test points were executed:

1. Programmable Signal Processor (PSP) Simulation
2. Navigation Simulation
 3. Radar Simulation and Reporting in Real, Mixed, and Virtual Modes
 4. Mixing of MTI Radar Virtual Entities with Standard E-8C Graphics Presentation
 5. Real and Virtual SAR Reports
 6. Normal Joint STARS Operator Functionality While Running VSTARS
7. Ground Interface Unit (GNIU) Processing Rate

For the Preliminary Assessment Test, the VSTARS default values were input according to Table 0-1 below.

Table 0-1 - VSTARS Default Values

1 - Turn off PD (Probability of Detection)	F (False)
2 - Turn off PFA (Probability of False Alarms)	F (False)
3 - Turn off CEP (Circular Error of Probability)	F (False)
4 - Turn off CEP of X-RNG and D-RNG Bias	F (False)
5 - Turn off Terrain Screening	F (False)
6 - Display Mixed Mode in Same Area	F (False)
7 - Display Dummy Targets	F (False)
8 - Minimum Detectable Velocity (M/S)	Set to 0 for scenario
9 - Minimum CEP Cross Range Error	Classified
10 - Minimum CEP Down Range Error	Classified
11 - Minimum PFA	Classified
12 - Minimum PD Cross Loss (dB)	Classified
13 - Monitoring Virtual Data ID (-1 for all)	-1

3. TEST RESULTS SUMMARY

The results of the Preliminary Testing of VSTARS is illustrated in Table 0-2. The table lists the seven test points evaluated along with their sub-categories.

Table 0-2. - Test Results Summary

TEST POINT	PASSED	FAILED	CORRECTIVE ACTION	STR NUMBER
1. Programmable Signal Processor (PSP) Simulation	X		None	N/A
• “Live” MTI and false alarms are displayed in the GRCA.	X		None	N/A
• Activity is shown in the PSP fields of the PKXOCO window.	X		None	N/A
2. Navigation Simulation	X		None	N/A
• Verify position updates in the System Information window.	X		None	N/A
• Ground truth is updating in the Navigation Monitor Sensors window.	X		None	N/A
• Navigation Status updates in the Navigation Monitor of PKXOCO.	X		None	N/A
3. Radar Simulation and Reporting in Real, Mixed, and Virtual Modes	X		None	N/A
• VSTARS displays “live” MTI radar on the Graphics Display (GD).	X		None	N/A
• VSTARS displays only virtual MTI radar on the Graphics Display	X		None	N/A
• VSTARS displays virtual and “live” MTI radar in both the live and virtual ACs and the GRCA.	X		None	N/A
4. Mixing of MTI Radar Virtual Entities with Standard E-8C Graphics Presentation	X		None	N/A

TEST POINT	PASSED	FAILED	CORRECTIVE ACTION	STR NUMBER
Graphic Features are displayed at every expansion.	X		None	N/A
All available Geographical Data is displayed on the Graphic Display.	X		None	N/A
SARs available in the SAR File Select are shown on the GD.	X		None	N/A
5. Real and Virtual SAR Reports		X	Fixed on the spot via a software patch.	#30484
Live SARs are displayed on the GD at proper orientation from the aircraft with acceptable fidelity. Because this is in the lab, live SARs are just noise.	X		None	N/A
Virtual SARs are displayed on the GD at proper orientation from the aircraft with acceptable fidelity using the SAR Simulation.	X		None	N/A
Mixed SARs are displayed on the GD at proper orientation from the aircraft with acceptable fidelity using the SAR Simulation.		X	Live SARs were displayed instead of virtual. This was changed on the spot so that mixed SARs are displayed using the SAR Simulation.	#30484
6. Normal Joint STARS Operator Functionality While Running VSTARS		X	STRs written for two functions that did not work.	#30485 #30486
Route functionality is available while running VSTARS.	X		None	N/A
E-Track functionality is available while running VSTARS.	X		None	N/A
A-Track functionality is available while running VSTARS.	X		None	N/A

TEST POINT	PASSED	FAILED	CORRECTIVE ACTION	STR NUMBER
History Playback functionality is available while running VSTARS.	X		None	N/A
Order of Battle functionality is available while running VSTARS.	X		None	N/A
Engagement Point functionality is available while running VSTARS.	X		None	N/A
Radar Screening functionality is available while running VSTARS.	X		None	N/A
User Defined Activity functionality is available while running VSTARS.	X		None	N/A
Timeline Impact functionality is available while running VSTARS.		X	Prevent PFZTLP process from crashing when performing Timeline Impact in the Flight Path Mode.	#30485
Update Radar Status functionality is available while running VSTARS.	X		None	N/A
Jammer Sector functionality is available while running VSTARS.	X		None	N/A
Sector and Area Blanking functionality is available while running VSTARS.	X		None	N/A
Bearing and Range functionality is available while running VSTARS.	X		None	N/A
Locate Entity functionality is available while running VSTARS.	X		None	N/A

TEST POINT	PASSED	FAILED	CORRECTIVE ACTION	STR NUMBER
Point functionality is available while running VSTARS.		X	Prevent the PTMWND process from crashing the windows handler when the Point function is activated.	#30486
Cursor Coordinate functionality is available while running VSTARS.	X		None	N/A
7. Ground Interface Unit (GNIU) Processing Rate	X		Request by JADS JTF to change DIS Monitor format.	#30487
With recording turned off, and a rate of 300 selected, PDUs are played back at a rate of 300 PDUs per second.	X		None	N/A
With recording turned off, and a rate of 500 selected, PDUs are played back at a rate over 350 PDUs per second.	X		None	N/A
With enhanced recording turned on, PDUs are played back at a rate over 350 PDUs per second.	X		None	N/A
With recording turned off, and a rate of 768 selected PDUs are played back at a rate over 350 PDUs per second.	X		None	N/A

4. TEST RESULTS

4.1 Programmable Signal Processor (PSP) Simulation

The PSP Simulator will receive setup and parameter data from the Radar Data Processor (RDP). It will generate node 1 data (target data) messages and send them to the RDP for target association.

JADS processes including Navigation Simulation, MTI Simulation, SAR Simulation, and Operations and Control Operation Task were initialized and the system was put into the operate mode. Distributed Interface Simulation (DIS) was not activated so that only PSP generated targets were displayed. A Ground Reference Coverage Area (GRCA) was created and approved. "Live" MTI radar was displayed in the GRCA indicating active PSPs. In addition, PSP activity was verified in the PKXOCO window under the PSP 1, 2, and 3 activity fields.

4.2 Navigation Simulation

The Navigation Simulation will simulate the position, altitude, and speed of an E-8C aircraft flying a specified orbit. It also will provide this data to the navigation software associated with the radar function. Additionally, it will provide required data, reports, and messages to the radar subsystem as required by the RDP.

To verify Navigation Simulation operation, the E-8C System Information window was observed for updates to platform position. Also, in the Simulation Navigation window, the Sensor's Monitor was displayed to show ground truth updates. Finally, in PKXOCO process window, the Nav Monitor was accessed to confirm that nav status was updating. The Navigation Simulation sent required updates to the navigation software.

4.3 Radar Simulation and Reporting in Real, Mixed, and Virtual Modes

VSTARS MTI simulation will operate in three modes: only live targets displayed, mixed (live and virtual) displayed, and virtual targets only displayed. The difference between live and virtual targets will not be visually distinguishable.

The first set of procedures under this test were used to verify the ability of VSTARS to operate in the live only mode. Prior to testing, two areas were created to display live targets. One was a live only area and the other was mixed, live and virtual. Distributed Interactive Simulation (DISSIM) and SGI (Silicon Graphics Indy) play back were not initialized. False alarms were turned off and PSP load was set to 90% in order to make live areas more visible. History playback was turned on and set in the integrate mode. In both of the areas, live targets were clearly visible.

The next step was to operate in the virtual only mode. PSP activity was set to 0 to stop "live" processing. False Alarms were then turned off to make it easier to see virtual targets. The DIS

Monitor and Interface Unit was activated to enable the processing of Protocol Data Units (PDUs) across the Large Area Network (LAN). A TELNET connection was made to the SGI, and the JADS Player was started to replay a stored scenario file. Finally, an Attack Control (AC) area was initiated over the virtual area to increase the update rate and probability of detection. Only virtual targets were displayed on the Graphics Display (GD).

The final procedure demonstrated that both mixed and virtual targets could be shown at the same time on the GD. With the SGI scenario running, selection was made to mix live and virtual data. The PSP load was reset to the default of 15% capacity and false alarms were turned back on. The virtual targets from the scenario continued to display along with the targets in the live and mixed areas.

4.4 Mixing of MTI Radar Virtual Entities with Standard E-8C Graphics Presentation

The VSTARS will permit the mixing of MTI radar virtual entities, terrain, and SAR images seamlessly with the actual radar images produced by the E-8C.

Live "noise" targets and virtual targets replayed via the Silicon Graphics machine were displayed on the Graphics Display. While running in the mixed mode, Graphics Features and Graphics Underlays were displayed successfully at all scale expansions. Following the display of standard graphical features, the SAR File Selection List was accessed to select previously recorded SAR files for exhibition on the Operator Workstation. Standard E-8C Graphics and SARs were successfully integrated with mixed MTI and virtual entities.

4.5 Real and Virtual SAR Reports

VSTARS will permit the SAR report to consist of either a live report or a virtual report. If the center position of the SAR falls within a virtual area, the SAR will be virtual. If it falls within a live area, the SAR will be live, and if it falls within a mixed area, the SAR will be virtual.

Virtual SARs were tested first. At each portion of the E-8C orbit: Eastern, Central, and Western, two virtual SARs were requested and approved. All six of these SARs were displayed on the graphics display at proper orientation from the aircraft and at acceptable fidelity.

The next SAR requested was in the location of fixed virtual targets. Upon display of the SAR, simulated cartographic data was shown along with bright spots representing the fixed targets as expected.

Live SARs were then tested, within the live only area. At each portion of the E-8C orbit: Eastern, Central, and Western, two live SARs were requested and approved. The live SARs were displayed at proper orientation as noise because the test was run in the laboratory setting without a radar sensor.

The purpose of the final step was to test SARs in a mixed area. At each portion of the E-8C orbit: Eastern, Central, and Western, two mixed SARs were requested and approved. The SARs in the mixed areas were displayed as live SARs as designed by Northrop Grumman. However, at this point it was stated that JADS JTF required SARs in mixed areas to be virtual instead of live. A software patch was installed to temporarily correct the problem. A Software Trouble Report (STR) #30484, was written to enable virtual only SARs in mixed areas. This functionality will be re-tested in Phase II.

4.6 Normal Joint STARS Operator Functionality While Running VSTARS

In all modes of operation, VSTARS will permit all the installed operator workstation software to function without the occurrence of abnormal fault messages caused by VSTARS.

Various Joint STARS operator functions were examined to verify that VSTARS did not interfere with their operation. The route function was the first application tested. Both cartographic and arbitrary routes were initialized and modified. The cartographic route was deleted. Route functionality is available while running VSTARS.

Tracking functionality was then demonstrated. A constrained extrapolated track (E-Track) was initiated using the "radar derived" option and the "segment method" to determine the target centroid. After successful E-Track initiation, an unconstrained Automated Track (A-Track) was initiated using "specified speed and course" and the "center method" to determine the target centroid. A second A-Track was then initiated using the "differential position" option and the "box method" to determine the target centroid. The second A-Track was selected for automatic repositioning with its associated Attack Control (AC) area. Both E-Track and A-Track functionality were available while running VSTARS.

The next function verified was history playback. History was selected in the integration mode, by frame, and set to start 10 minutes prior to current system time. MTI history was displayed continuously. At this point, history was paused and sliding window was selected as well as integration. The window size and advance were set to 10 and history replay was restarted. History playback showed only the selected window of the integration as expected. Then, history was paused again and both integrate and sliding window were deselected. When restarted, history played back in the non-integrated mode. History Playback functionality is available while running VSTARS.

Order of Battle capability was demonstrated. Order of Battle points, lines, and areas were all created, modified, and deleted. Normal Order of Battle functionality is available while running VSTARS.

Engagement Point (EP) operability was confirmed. First, a base engagement point was created. In order to pair the engagement point, an E-Track was initiated 15 km in front of the base engagement point. The existing EP was associated to the E-Track. A red EP was shown on the GD, and time of arrival information was displayed in the Time of Arrival (TOA) data field as usual. Engagement Point functionality is available while running VSTARS.

The next capability demonstrated was Radar Screening. With the SGI scenario replay continuing, an A-Track was initiated on virtual targets. The Radar Screening was accessed and the fixed ground point option was selected. Upon depressing the ENTER key, a magenta line was displayed on the flight path indicating the target was visible. As with typical Joint STARS missions, the turn was shown as cyan to indicate the target would not be visible. For the next step, the route segment option was chosen. Upon depressing the ENTER key, the selected route segment was colored magenta indicating that the route segment was not screened. Route Screening functionality is available while running VSTARS.

User Defined Activity Areas (UDA) were verified next. A UDA with a threshold of 5 was built 5 kilometers in front of a virtual target group. The 4 X 4 UDA appeared on the GD. When more than 5 targets entered the UDA, an alert "UDA THRESHOLD EXCEEDED" was displayed, and the UDA border thickened. User Defined Activity functionality is available while running VSTARS.

The next step was to confirm the functionality of Timeline Impact. The Timeline Impact Tabular Display (TL IMPACT TD) was selected from the Process RSR push-button menu. The Flight Path (FP) option was selected. Projected time for the simulated E-8C was input, and the start time set for two minutes later. The chosen duration was 60 minutes and all RSRs were selected for impact analysis. Upon depressing the ENTER key, this software application timed out and died. The process was restarted, but again, the application timed out and died. The test was run again after the Assessment Test without any of the VSTARS processes running. Again, this process did not work. An STR (#30485) has been written to correct this problem. This test will be re-run in Phase II.

Update Radar Status was the next function to verify. The Approved RSR List TD was displayed on the GD for monitoring. The Update Radar Status button was depressed, and immediately, the Approve List was updated. The Update Radar Status functionality is available while running VSTARS.

Jammer Sector was tested next. The Jammer Sector TD was selected from the Radar Management push-button menu. A jammer sector was displayed on the GD as a wedge centered at the indicated position. Jammer Sector functionality is available while running VSTARS.

The following steps confirmed the operation of Sector Blanking and Area Blanking. First, a Sector Blanking Service Request was initiated over SGI play back targets using a fixed ground point, azimuth width of 5, and duration of 0. After approval of the blanked sector, no targets were displayed in the sector. Then, an Area Blanking Service Request was initialized. Again, it was centered over virtual targets. Upon approval, a 10 X 10 blanked area was displayed on the GD. There were no target detections in the area. The Sector and Area Blanking functionality are available while running VSTARS.

The last step in this test was to ensure that the functions available from the pull-down menu were available with VSTARS running. Bearing and range and free form were the first applications

tested. Both worked as expected. Next, locate entity was selected using an RSR number for input. A large arrow appeared on the GD identifying the location of the requested RSR. The next application was the Point function. Upon selection of this option, window handler crashed and restarted. This application is not available on the Alpha 600 at this time. An STR (#30486) has been written and will be re-run in Phase II. Cursor Coordinate functionality was tested next. A position was input. When the ENTER key was depressed, the position was converted into available coordinate systems within the TD. All pull-down menu functions were available while running VSTARS except the point function.

4.7 Ground Interface Unit (GNIU) Processing Rate

The Ground Interface Unit (GNIU) receives and processes DIS 2.0.4 Entity State Protocol Data Units (ESPDUs) at a rate greater than 350 ESPDUs per second.

The JADS Player on the SGI was used to replay protocol data (PDUs) units at various rates to show the GNIU can exceed 350 ESPDUs per second. At the various rates recording was turned off, set to a simplified recording level of 1, or the enhanced recording level of 2. The PDU rate was monitored via the DIS Monitor window. This window is displayed in hex and updates every two seconds. As requested by JADS JTF, an STR (#30487) was written to label DIS Monitor columns and convert hex numbers to decimal.

Table 0-3 displays the results of the this test. The first replay rate used was a rate of 300 with recording turned off. The Average number of PDUs was 300. Next, the rate was set to 500. With recording turned off, the number of PDUs replayed was 500; with recording set to 1, the replay rate averaged 455, and with level 2, the rate averaged 450. The final recording rate selected was 768 with recording turned off. The PDU rate per second averaged 750. This test verified that the GNIU processing rate exceeds 350 PDUs per second.

Table 0-3 - GNIU Processing Rate

r-300 recording off

Hex Number	Decimal	Difference	Per 2 Sec
9ff8	40952	598	299
9da2	40354	607	303.5
9b43	39747	591	295.5
98f4	39156	594	297
96a2	38562	38562	19281

r-500 recording off

Hex Number	Decimal	Difference	Per 2 Sec
1a62	6754	1003	501.5
1677	5751	996	498
1293	4755	999	499.5
eac	3756	1001	500.5
ac3	2755	999	499.5
6dc	1756	1000	500
2f4	756	756	378

r-500 recording set to 1

Hex Number	Decimal	Difference	Per 2 Sec
11c6	4550	992	496
de6	3558	995	497.5
a03	2563	994	497
621	1569	994	497
23f	575	575	287.5

r-500 recording set to 2

Hex Number	Decimal	Difference	Per 2 Sec
20d2	8402	900	450
1d4e	7502	896	448
19ce	6606	893	446.5
1651	5713	896	448
12d1	4817	894	447
f53	3923	899	449.5
bd0	3024	893	446.5
853	2131	2131	1065.5

r-768 recording off

Hex Number	Decimal	Difference	Per 2 Sec
2e2c7	189127	1496	748
2dcef	187631	1498	749
2d715	186133	1499	749.5
2d13a	184634	1497	748.5
2cb61	183137	1503	751.5
2c582	181634	1503	751.5
2bfa3	180131	1506	753
2b9c1	178625	178625	89312.5

Average PDU Rate Per Second

299 r-300 recording off

500 r-500 recording off

455 r-500 recording 1

448 r-500 recording 2

750 r-768 recording off

5. PHASE I ASSESSMENT TEST SUMMARY

Overall, the Phase I Assessment Test was successful. Out of over 200 procedural steps, only three failed. Of these three, the mixed area SARs have already been corrected, and Timeline Impact and the Point function are considered to be minor problems. In addition to test findings, JAD JTF also requested a more user friendly DIS Monitor. For example, the columns should be labeled and the numbers in decimal format versus hex format. After the Software Trouble Reports (#30484, 30485, 30486, 30487) are incorporated, the three failed areas mentioned above will be re-run during Phase II testing.

Appendix D

Characterization Reports From JADS JTF/ETE (N&E)

MEMORANDUM FOR RECORD

16 Dec 97

FROM : JADS JTF/ETE(N&E)

SUBJECT: Characterization Report

1. Event Name: TCAC-Grumman T-1 Characterization.
2. Date/Time: 1 Dec 97; 1100 - 1500.
3. Site(s): Grumman - Melbourne, FL; JADS TCAC - Albuquerque, NM.
4. Description: The characterization involved base-lining the performance of the T-1 link between Grumman and the TCAC. A variety of Networking and Engineering tests were used to calculate the round trip latencies and determine the maximum rate at which DIS PDUs could be transmitted before drop-outs occurred. The tests used to gather this data included the No Load Latency Test, the Loaded Latency Test, PDU Verification Test and the Stress Test. Additionally, Spectrum recorded the bandwidth utilized across the T-1 link.
5. Objective: Assess (characterize) the TCAC-Grumman T-1 Link with and without network analysis tools operating.
 - 5.1 Determine the "no load" latency using pings.
 - 5.2 Determine the loaded latency using pings at varying rates.
 - 5.3 Successful transmission of DIS PDUs across the link.
 - 5.4 Determine the packet rate (packets per second) in which DIS PDUs are lost.
 - 5.5 Determine the impact of Spectrum on latencies and data rates.

6. Results:

6.1. Data Recorded (**with** Spectrum operational)

6.1.1 No Load Latency Test: The first test conducted was the no load latency test using *pings*. This test involved using 32 *pings* for measuring the baseline round trip latency from the TCAC to Grumman. The minimum load for these pings were 64 bytes. This test yielded the following results:

Table 6.1.1. Latency Test - No Load

Date	Source	Destination	No. Pkts	Round-trip Time (ms)		
				Minimum	Maximum	Average
1 Dec 97	TCAC_Indy	Grumman_Indy	32	57	71	57

6.1.2. Loaded Latency Test: The second test consisted of transmitting loaded pings, 144 bytes, at several different rates and packet sizes to determine the round trip latencies— see table 6.1.2.

Table 6.1.2. Latency Test - Loaded

Date	Source	Destination	Pkt Rate(sec)	Pkts Sent/Rec	Round-trip Time (ms)		
					Min	Max	Ave
1 Dec 97	TCAC_Indy	Grumman_Indy	.01	320/320	58	163	60
			.005	640/639	58	61	58
			.0025	1280/1279	58	124	58
			.00125	2560/2559	58	167	58

6.1.3. PDU Verification Test: The next test used PDUs generated at 100 packets per second from JANUS and recorded by the JADS logger. The PDUs were replayed from the TCAC and logged at Grumman – see table 6.1.3.

Table 6.1.3. PDU Verification Test

Date	Location	No. of PDUs Received	No. of PDUs Transmitted	No. of PDUs Out-of-order	No. of PDUs > 1 sec.
5 Nov 97	Grumman	11859	11859	0	0

6.1.4. Stress Test: This test involved replaying the ESPDU file at its recorded expected data rate (EDR), then increasing the EDR by 100 packets per second incrementally to five times the EDR. During the actual playback of the PDU log file, *pings* were transmitted and latency statistics recorded. Spectrum also recorded the bandwidth utilized.

Table 6.1.4. Stress Test

	Rate (PDU/sec)	Ping Time (ms) Min/Max/Ave	Number PDUs Received	Bandwidth Util. (%)
1 X E.R.	100	60/120/61	11859	10
2 X E.R.	200	59/90/68	11858	21
3 X E.R.	300	59/90/64	11853	28
4 X E.R.	400	57/210/79	11847	40
5 X E.R.	500	57/840/256	10492	45

6.2. Data Recorded (**without** Spectrum operational)

6.2.1 No Load Latency Test: The first test conducted was the no load latency test using *pings*. This test involved using 32 *pings* for measuring the baseline round trip latency from the TCAC to Grumman. The minimum load for these *pings* were 64 bytes. This test yielded the following results:

Table 6.2.1. Latency Test - No Load

Date	Source	Destination	No. Pkts	Round-trip Time (ms)		
				Minimum	Maximum	Average
1 Dec 97	TCAC_Indy	Grumman_Indy	32	57	76	57

6.2.2. Loaded Latency Test: The second test consisted of transmitting loaded *pings*, 144 bytes, at several different rates and packet sizes to determine the round trip latencies— see table 6.2.2.

Table 6.2.2. Latency Test - Loaded

Date	Source	Destination	Pkt Rate(sec)	Pkts Sent/Rec	Round-trip Time (ms)		
					Min	Max	Ave
1 Dec 97	TCAC_Indy	Grumman_Indy	.01	320/320	58	60	58
			.005	640/639	58	64	58
			.0025	1280/1279	58	101	58
			.00125	2560/2559	58	161	58

6.2.3. PDU Verification Test: The next test used PDUs generated at 100 packets per second from JANUS and recorded by the JADS logger. The PDUs were replayed from the TCAC and logged at Grumman – see table 6.2.3.

Table 6.2.3. PDU Verification Test

Date	Location	No. of PDUs Received	No. of PDUs Transmitted	No. of PDUs Out-of-order	No. of PDUs > 1 sec.
5 Nov 97	Grumman	11859	11859	0	0

6.2.4. Stress Test: The last test conducted was the Stress Test. The test involved replaying the ESPDU file at its recorded EDR, then increasing the EDR by 100 packets per second incrementally to five times the EDR. During the actual playback of the PDU log file, *pings* were transmitted and latency statistics recorded; however, bandwidth data was not collected.

Table 6.2.4. Stress Test

	Rate (PDU/sec)	Ping Time (ms) Min/Max/Ave	Number PDUs Received	Bandwidth Util. (%)
1 X E.R.	100	60/70/60	11859	
2 X E.R.	200	58/92/62	11858	
3 X E.R.	300	59/89/63	11853	
4 X E.R.	400	57/120/71	11848	
5 X E.R.	500	57/600/216	10759	

6.3. Problems:

6.3.1. The characterization process was delayed for a couple of hours due to the monthly crypto reloading.

6.3.2. During the PDU Verification test additional DIS PDUs were being logged at the Grumman_Indy computer. The DIS PDUs logged at Grumman exceeded the number contained in the replayed log file sent from the TCAC. The Grumman_Indy computer can receive data from both Grumman and the TCAC. The test coordinator contacted Grumman and inquired as to whether they had a system broadcasting to the Grumman_Indy computer on port 3000. Grumman's initial response to our question was no. Upon our investigation, which consisted of viewing traffic along port 3000, we observed the Grumman_Indy computer receiving data long after we had stopped broadcasting. Apparently, Grumman had concluded a test last week, but their Alpha computer was still sending data to port 3000. Finally, Grumman disconnected their Alpha computer and we resumed testing with no further problems or delays.

6.3.3. The IDNX router card throughput is presently less than the vendor's specification and the allocated capacity of the T-1 link. The performance can be improved if we used bridging as opposed to Internet Protocol (IP) routing of DIS PDUs. This procedure was assessed using the JADS testbed. The effect of bridging doubled the reliable transmitted data rate to 800 packets per second. However, this configuration does not support the current network design of the ETE test. The vendor was contacted about the shortcoming, and they are pursuing every avenue to determine if the performance problem is their software, Cisco's software, or hardware related.

6.3.4. Although the utilized bandwidth was accurately recorded using Spectrum for one, two, and three times the EDR, the values for four and five times seemed lower than expected. The percentages were 20 and 19, respectively. The data collection sampling interval was initial set for every 30 seconds. Consequently, the DIS PDUs were not replayed within the time window and the results were not representative of the EDR. The settings were reduced to 10 second intervals and Spectrum's packet rate data was monitored to ensure the values reflected the EDR.

6.3.5. The maximum value recorded for each set of pings represented an outlier of the data set. This maximum value far exceeded the values recorded and consistently appeared at the

beginning of the recorded data set. Since this anomaly happened infrequently during a ping data set, the results were not statistically significant. N&E will continue to investigate this issue.

6.4. Summary: At 1000hrs the characterization team began the preliminary checks of the network. About one hour later, the characterization began and each one of the tests was executed in sequence. The test results were stable and fairly predictable. During the Stress Test several DIS PDUs were lost at three and four times the EDR but did not achieve a notable percentage. However, at five times the EDR several hundred DIS PDUs were dropped--approximately nine percent. Currently, the highest EDR transmissions across this link should not exceed 400 packets per second; therefore, the link can successfully handle the expected traffic. The characterization test also involved capturing the impact of the network analysis tool. The results indicated that Spectrum minimally increased the amount of network traffic and added an insignificant amount of latency.

GREGORY P. DEWIT
CPT(P), FA
Test Analyst

26 Feb 98

FROM : JADS JTF/ETE/N&E

SUBJECT: ETE Characterization Report

1. Event Name: White Sands Missile Range (WSMR)/TCAC-A Annex T-1 Characterization.
2. Date/Time: 3 Feb 98; 1100 - 1500.
3. Sites: WSMR, NM; JADS TCAC - Albuquerque, NM.
4. Description: The characterization involved base-lining the performance of the T-1 link between WSMR and the TCAC-A. A variety of Networking and Engineering tests were used to calculate the round trip latencies and determine the maximum rate at which DIS PDUs could be transmitted before drop-outs occurred. The tests used to gather this data included the No Load Latency Test, the Loaded Latency Test, PDU Verification Test, and the Stress Test.
5. Objective: Assess (characterize) the WSMR/TCAC-A T-1 link.
 - 5.1 Determine the "no load" latency using pings.
 - 5.2 Determine the loaded latency using pings at varying rates.
 - 5.3 Successful transmission of DIS PDUs across the link.
 - 5.4 Determine the packet rate (packets per second) in which DIS PDUs are lost.

6. Results:

6.1. Data Recorded.

6.1.1 No Load Latency Test: The first test conducted was the no load latency test using *pings*. This test involved using 32 *pings* for measuring the baseline round trip latency from the TCAC to WSMR. The minimum load for these pings were 64 bytes. This test yielded the following results:

Table 6.1.1. Latency Test - No Load

Date	Source	Destination	No. Pkts	Round-trip Time (ms)		
				Minimum	Maximum	Average
1 Dec 97	TCAC_Indy	WSMR Indy	32	41	44	41

6.1.2. Loaded Latency Test: The second test consisted of transmitting loaded pings, 144 bytes, at different rates and packet sizes to determine round trip latencies— see table 6.1.2.

Table 6.1.2. Latency Test - Loaded

Date	Source	Destination	Pkt Rate(sec)	Pkts Sent/Rec	Round-trip Time (ms)		
					Min	Max	Ave
1 Dec 97	TCAC_Indy	WSMR Indy	.01	320/320	42	45	42
			.005	640/639	42	85	42
			.0025	960/960	42	51	42

6.1.3. PDU Verification Test: The next test used PDUs generated at 100 packets per second from JANUS and recorded by the JADS logger. The PDUs were replayed from the TCAC and logged at WSMR – see table 6.1.3.

Table 6.1.3. PDU Verification Test

Date	Location	No. of PDUs Received	No. of PDUs Transmitted	No. of PDUs Out-of-order	No. of PDUs > 1 sec.
5 Nov 97	WSMR	11859	11859	0	0

6.1.4. Stress Test: This test involved replaying the ESPDU file at its recorded expected data rate (EDR), then increasing the EDR by 100 packets per second incrementally to five times the EDR. During the actual playback of the PDU log file, *pings* were transmitted and latency statistics recorded. Spectrum also recorded the bandwidth utilized.

Table 6.1.4. Stress Test

	Rate (PDU/sec)	Ping Time (ms) Min/Max/Ave	Number PDUs Received
1 X E.R.	100	59/61/59	11859
2 X E.R.	200	41/61/59	11858
3 X E.R.	300	41/60/45	11853
4 X E.R.	400	41/61/58	11850
5 X E.R.	500	41/70/56	11849

6.2. Problems: PDUs were lost during the execution of the Stress Test. N&E continues to investigate packet drop-outs.

6.3. Summary: During the execution of the characterization, latencies and PDU drop-outs were less than anticipated. Unlike several other T-1 links characterized while using a routed network configuration, WSMR used bridging. This technique provided a much more stable environment thus allowing for lower transmission latencies and fewer PDU losses. Each characterization test was conducted and the results annotated in the previous tables. The WSMR/TCAC-A link can support the maximum expected data rate of 400 PDUs per second.

GREGORY P. DEWIT
CPT(P), FA
Test Analyst

MEMORANDUM FOR RECORD

26 Feb 98

FROM : JADS JTF/ETE/N&E

SUBJECT: Characterization Report

1. Event Name: Fort Hood/TCAC-A Annex T-1 Characterization.
2. Date/Time: 2 Feb 98; 0900 - 1100.
3. Sites: Fort Hood, TX; JADS TCAC - Albuquerque, NM.
4. Description: The characterization involved base-lining the performance of the T-1 link between Fort Hood and the TCAC-A. A variety of Networking and Engineering tests were used to calculate the round trip latencies and determine the maximum rate at which DIS PDUs could be transmitted before drop-outs occurred. The tests used to gather this data included the No Load Latency Test, the Loaded Latency Test, PDU Verification Test, and the Stress Test.
5. Objective: Assess (characterize) the Fort Hood/TCAC-A T-1 link.
 - 5.1 Determine the "no load" latency using pings.
 - 5.2 Determine the loaded latency using pings at varying rates.
 - 5.3 Successful transmission of DIS PDUs across the link.
 - 5.4 Determine the packet rate (packets per second) in which DIS PDUs are lost.
6. Results:
 - 6.1. Data Recorded.

6.1.1 No Load Latency Test: The first test conducted was the no load latency test using *pings*. This test involved using 32 *pings* for measuring the baseline round trip latency from the TCAC to Fort Hood. The minimum load for these pings were 64 bytes. This test yielded the following results:

Table 6.1.1. Latency Test - No Load

Date	Source	Destination	No. Pkts	Round-trip Time (ms)		
				Minimum	Maximum	Average
1 Dec 97	TCAC_Indy	Fort Hood Indy	32	37	77	38

6.1.2. Loaded Latency Test: The second test consisted of transmitting loaded pings, 144 bytes, at several different rates and packet sizes to determine the round trip latencies— see table 6.1.2.

Table 6.1.2. Latency Test - Loaded

Date	Source	Destination	Pkt Rate(sec)	Pkts Sent/Rec	Round-trip Time (ms)		
					Min	Max	Ave
1 Dec 97	TCAC_Indy	Fort Hood Indy	.01	320/320	38	39	38
			.005	640/639	39	55	39
			.0025	960/960	38	76	39

6.1.3. PDU Verification Test: The next test used PDUs generated at 100 packets per second from JANUS and recorded by the JADS logger. The PDUs were replayed from the TCAC and logged at Fort Hood – see table 6.1.3.

Table 6.1.3. PDU Verification Test

Date	Location	No. of PDUs Received	No. of PDUs Transmitted	No. of PDUs Out-of-order	No. of PDUs > 1 sec.
5 Nov 97	Fort Hood	11859	11859	0	0

6.1.4. Stress Test: This test involved replaying the ESPDU file at its recorded excepted data rate (EDR), then increasing the EDR by 100 packets per second incrementally to five times the EDR. During the actual playback of the PDU log file, *pings* were transmitted and latency statistics recorded. Spectrum also recorded the bandwidth utilized.

Table 6.1.4. Stress Test

	Rate (PDU/sec)	Ping Time (ms)		Number PDUs Received
		Min/Max/Ave		
1 X E.R.	100	40/69/59		11859
2 X E.R.	200	37/60/42		11858
3 X E.R.	300	50/60/59		11853
4 X E.R.	400	38/61/58		11859
5 X E.R.	500	37/61/54		11859

6.2. Problems: PDU drop-out is a reoccurring problem during the Stress Test. N&E is still investigating.

6.3. Summary: The Fort Hood/TCAC-A bridged link was characterized in less than four hours. The appropriate data was gathered and appears in the tables mentioned earlier. There latencies were stable throughout the execution of each test. The link can support more than the maximum expected data rate with only a couple of PDUs dropped. A bridged network seems to offer faster transmission rates and fewer PDU drop-outs.

GREGORY P. DEWIT
CPT(P), FA
Test Analyst

MEMORANDUM FOR RECORD

26 Feb 98

FROM : JADS JTF/ETE/N&E

SUBJECT: Characterization Report

1. Event Name: Fort Sill/TCAC-A Annex T-1 Characterization.
2. Date/Time: 2 Feb 98; 1300 - 1600.
3. Sites: Fort Sill, OK; JADS TCAC - Albuquerque, NM.
4. Description: The characterization involved base-lining the performance of the T-1 link between Fort Sill and the TCAC-A. A variety of Networking and Engineering tests were used to calculate the round trip latencies and determine the maximum rate at which DIS PDUs could be transmitted before drop-outs occurred. The tests used to gather this data included the No Load Latency Test, the Loaded Latency Test, PDU Verification Test, and the Stress Test.
5. Objective: Assess (characterize) the Fort Sill/TCAC-A T-1 link.
 - 5.1 Determine the "no load" latency using pings.
 - 5.2 Determine the loaded latency using pings at varying rates.
 - 5.3 Successful transmission of DIS PDUs across the link.
 - 5.4 Determine the packet rate (packets per second) in which DIS PDUs are lost.
6. Results:
 - 6.1. Data Recorded.

6.1.1 No Load Latency Test: The first test conducted was the no load latency test using *pings*. This test involved using 32 *pings* for measuring the baseline round trip latency from the TCAC to Fort Sill. The minimum load for these pings were 64 bytes. This test yielded the following results:

Table 6.1.1. Latency Test - No Load

Date	Source	Destination	No. Pkts	Round-trip Time (ms)		
				Minimum	Maximum	Average
1 Dec 97	TCAC_Indy	Indy	32	30	40	30

6.1.2. Loaded Latency Test: The second test consisted of transmitting loaded pings, 144 bytes, at several different rates and packet sizes to determine the round trip latencies- see table 6.1.2.

Table 6.1.2. Latency Test - Loaded

Date	Source	Destination	Pkt Rate(sec)	Pkts Sent/Rec	Round-trip Time (ms)		
					Min	Max	Ave
1 Dec 97	TCAC_Indy	Indy	.01	320/320	31	33	31
			.005	640/639	31	33	31
			.0025	960/960	31	33	31

6.1.3. PDU Verification Test: The next test used PDUs generated at 100 packets per second from JANUS and recorded by the JADS logger. The PDUs were replayed from the TCAC and logged at Fort Sill – see table 6.1.3.

Table 6.1.3. PDU Verification Test

Date	Location	No. of PDUs Received	No. of PDUs Transmitted	No. of PDUs Out-of-order	No. of PDUs > 1 sec.
5 Nov 97	Fort Sill	11859	11859	0	0

6.1.4. Stress Test: This test involved replaying the ESPDU file at its recorded excepted data rate (EDR), then increasing the EDR by 100 packets per second incrementally to five times the EDR. During the actual playback of the PDU log file, *pings* were transmitted and latency statistics recorded. Spectrum also recorded the bandwidth utilized.

Table 6.1.4. Stress Test

	Rate (PDU/sec)	Ping Time (ms)	Number PDUs Received
		Min/Max/Ave	
1 X E.R.	100	30/61/58	11859
2 X E.R.	200	30/60/52	11857
3 X E.R.	300	30/61/43	11853
4 X E.R.	400	30/60/36	11859
5 X E.R.	500	30/84/300	10656

6.2. Problems: PDUs were lost during the execution of the Stress Test. N&E will continue to investigate packet drop-outs.

6.3. Summary: The Fort Sill/TCAC-A link involved using a router to transmit PDU packets. The latencies were reasonably close to the values during the Grumman Characterization given the shorter distance between Albuquerque and Fort Sill. There were a couple of packets lost while incrementing up to four times the EDR. The number of lost PDUs increased to about 10 percent of the packets transmitted at five times the EDR (500 packets per second).

GREGORY P. DEWIT
CPT(P), FA
Test Analyst

Appendix E
LWX and Cisco Router Performance Test Report

**Joint Advanced Distributed Simulation Joint Test Force
(JADS JTF)**

LWX and Cisco Router Performance Test Report

**SUBJECT: Integrated Digital Network Exchange
(IDNX) LAN/WAN Exchange (LWX) and
Cisco Router Performance Measurement in the
Broadcasting/Forwarding of
User Datagram Protocol Environment**

**AUTHOR: MSgt Charles P. Ashton, WAN Systems
Engineer, Joint Advanced Distributed
Simulation (JADS) Joint Test Force (JTF)**

**Mason S. Ferratt, Systems Engineer Network
Equipment Technologies (NET)**

DATE: December 18, 1997

SUMMARY: This is a report of the performance, validation, and verification testing conducted on the LWX and external Cisco router platforms at the JADS-JTF facility, Albuquerque, NM. This document covers the steps taken during testing, the test results, conclusions drawn, and a discussion of the alternative solutions for the broadcasting of User Datagram Protocol (UDP) traffic through the JADS JTF End-to-End (ETE) network.

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1. Background

The Joint Advanced Distributed Simulation Joint Test Force (JADS JTF) has built a network of seven nodes to support an environment linking multiple simulation sites whose primary application is the broadcasting of User Datagram Protocol packets from multiple sites to multiple sites. The network supports the evaluation of Advanced Distributed Simulation (ADS) for the Department of Defense (DOD) Test and Evaluation (T&E) Community. The system is called the End-to-End Test Network and the system under test is the Joint Surveillance and Targeting Attack Radar System (JSTARS) and its associated command and control functions. The services carried by this network include the router traffic and voice traffic.

The goal of the testing conducted December 15-16, 1997 was to provide answers to whether the PX platforms (PX-3, PX-2, and APX) provided by NET could support the demands of the UDP traffic load through the JADS network.

2. Scope of Testing

1. Verification/validation of the problems witnessed by TSGT Ashton
2. Comparison of the performance gains/losses of external router configurations
3. Effects of altering internal software configuration (buffers, hold queues, etc.)
4. Effects of using a hybrid routed/bridged network
5. Effects of a completely bridged network

3. Description of PX-3 and LWX Rel. 3.01

The LAN/WAN Exchange (LWX) Release 3.01 is a general purpose router/bridge integrated into the Integrated Digital Network Exchange (IDNX) platform. It provides internetwork connectivity between Local Area Networks (LANs) over Wide Area Networks (WANs) through IDNX/ 90, /70, /20, and /Micro 20 IDNX nodes. The LWX 3.01, consists of a PX3 front card (revision B or later) and an Ethernet or Token Ring interface rear card, and provides:

- concurrent multi-protocol routing and fallback Media Access Control (MAC) layer bridging
- up to 8 logical serial connections to other LWXs or external routers
- an Ethernet interface rear card

The first phase of LWX 3.01 only supports four and eight port PX3 cards. Earlier LWX versions consisted of a PX- 2, PX- Plus, or Access PX front card and an Ethernet or Token Ring interface rear card, and provide only eight logical serial connections to other LWXs or external routers. LWX Release 3.01 supports only Ethernet and Token Ring (available in a later release) interface cards. LWX Release 3.01 must use a revision B (or later) PX3 card.

The JADS network uses four port PX3, eight port PX-2, and four port APX cards. The PX-3s run LWX Release 3.01 and the PX-2s and APXs run LWX Release 2.02.06. The LWX Release

3.01 is equivalent to Cisco's IOS Release 11.0(9). The LWX Release 2.02.06 is equivalent to

4. Test Configurations

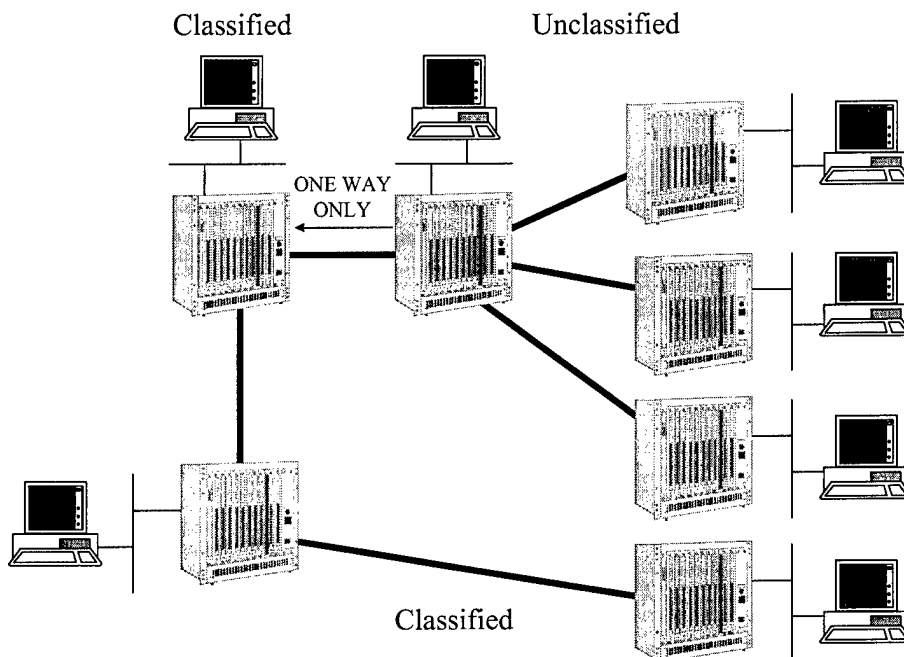


Figure 4-1 - JADS ETE Network Configuration

Figure 4-1 above illustrates a general configuration of the JADS ETE network. The connectivity between the nodes remained consistent throughout the testing. However, card and port configurations were varied for the different tests.

4.1 Point to Point PX-3

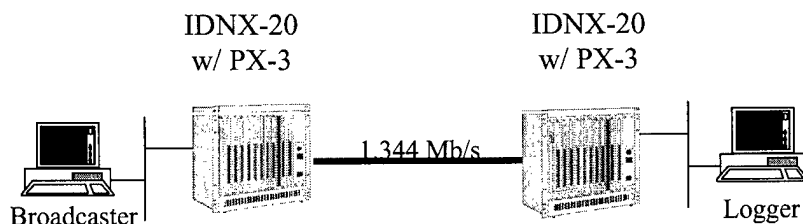


Figure 4.1-1 - PX-3 to PX-3 Configuration

Figure 4.1-1 above illustrates the setup used for the verification/validation using two PX-3s point-to-point.

4.2 Point to Point PX-3s to APX

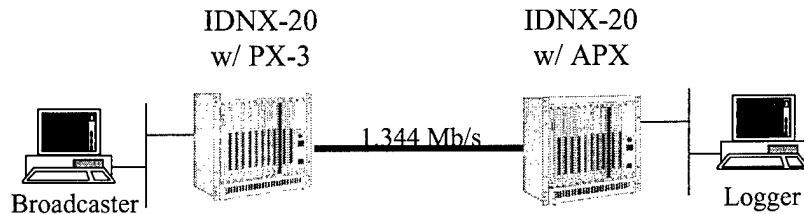


Figure 4.2-1 - PX-3 to APX Configuration

Figure 4.2-1 above illustrates the setup used for the verification/validation using one PX-3 and one APX point-to-point.

4.3 Cisco 4000 to PX-3

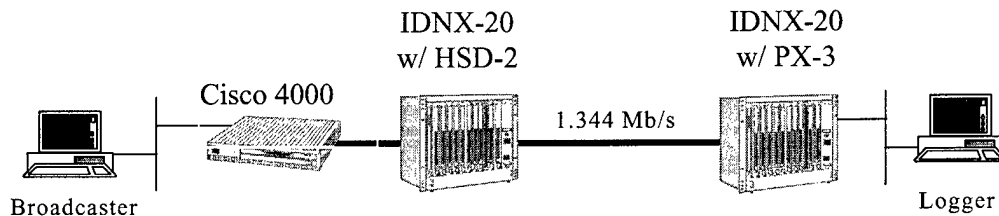


Figure 4.3-1 - Cisco 4000 to PX-3 Configuration

Figure 4.3-1 above illustrates the setup used for the verification/validation using an externally connected Cisco 4000 running Cisco IOS Release 9.1 to a PX-3 point-to-point. The Cisco 4000 was serially connected through an HSD-2 port on the IDNX. The HSD-2 port was mapped to the distant end PX-3.

4.4 Cisco 7000 to PX-3

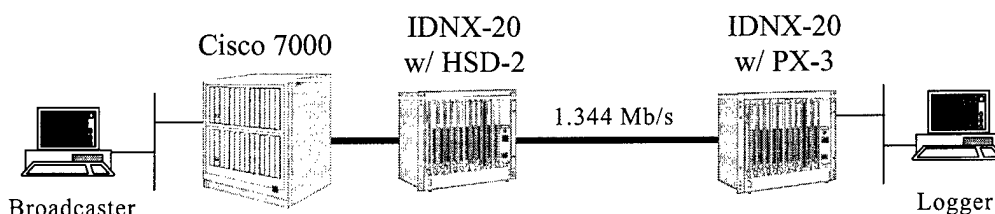


Figure 4.4-1 - Cisco 7000 to PX-3 Configuration

Figure 4.4-1 above illustrates the setup used for the verification/validation using an externally connected Cisco 7000 running Cisco IOS Release 11.x to a PX-3 point-to-point. The Cisco 7000 was serially connected through an HSD-2 port on the IDNX. The HSD-2 port was mapped to the distant end PX-3.

4.5 Cisco 7000 to 4000

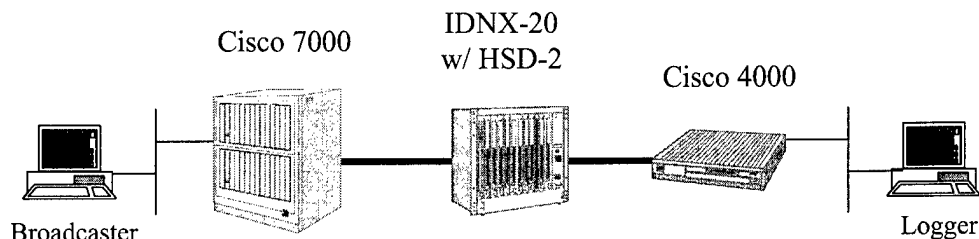


Figure 4.5-1 - Cisco 7000 to Cisco 4000 Configuration

Figure 4.5-1 above illustrates the setup used for the verification/validation using an externally connected Cisco 7000 running Cisco IOS Release 11.x to another externally connected Cisco 4000 point-to-point. Both Cisco routers were serially connected through HSD-2 ports on the IDNX. The HSD-2 ports were mapped end to end.

4.6 Multipoint UDP Forwarding & Hybrid Bridge/Router

IDNX-20
w/ PX-3

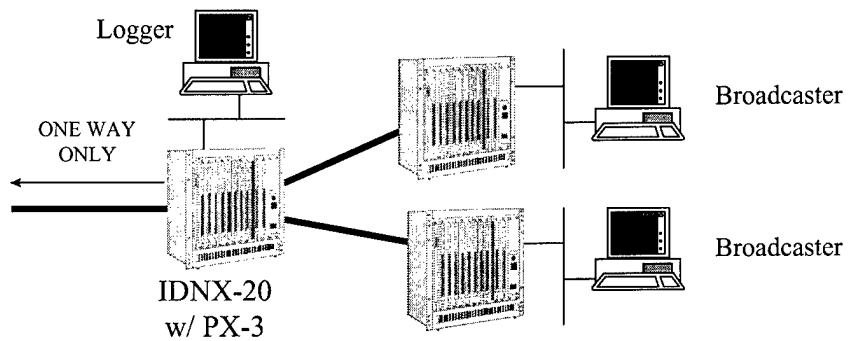


Figure 4.6-1 - Multipoint UDP Forwarding & Hybrid Bridge/Router Configuration

Figure 4.6-1 above illustrates the setup used for the verification/validation using multiple sources to broadcast DIS Entity State PDUs to a central logger. This configuration represents a portion of the unclassified side of the JADS ETE network.

5. Test Expectations

Throughout all the tests the Broadcaster, an SGI Indy workstation, used a file that consisted of 11,859 Distributed Interactive Simulation (DIS) Entity State protocol data units (PDUs). The SGI workstation broadcasted the PDUs on its local area network (LAN) as User Datagram Protocol (UDP) packets. The LWXs were configured to forward these broadcasts through the network. Each Entity State PDU was 144 bytes in length. The Internet Protocol (IP) datagram produced was 152 bytes in length. All this was verified using a Network General Sniffer Protocol Analyzer on the Broadcaster subnetwork.

At the distant end, the Logger, also an SGI Indy workstation, listened for UDP broadcasts and counted the number received. The difference is the number of packets dropped within the network.

We expected to see a threshold that each platform would reach in terms of performance. We knew that the unreliable nature of the traffic (UDP broadcasts) would force the routers to inspect each packet since it was a broadcast, and forward it onto each interface. This activity is known as process switching. The fact that every packet sent is process switched, we knew there had to be a limit to the number of packets successfully received when a workstation floods the network. We also expected to see very little improvement when changing the buffers and hold-queues. The fact remained that if packets are process-switched, there is a finite limit to speed in which it forwards packets successfully. We will discuss more about these issues in our conclusions.

The following two sections cover the result sets for the two separate environments (point-to-point and multipoint). The point-to-point environment results were used to gauge the expected results when we combined multiple stations broadcasting in the network. The multipoint configuration better represents the true network that will be fielded to support the JADS ETE network.

6. Performance Test Results (Point to Point - UDP forwarding)

Broadcaster generating 400 packets per second -

<i>Configuration</i>	<i>Packets Dropped (Broadcast Side)</i>	<i>Packets Dropped (Logger Side)</i>
PX-3 to PX-3	0	0
PX-3 to APX	0	0
Cisco 4000 to PX-3	0	0
Cisco 7000 to PX-3	0	0
Cisco 4000 to Cisco 7000	0	0
Cisco 7000 to Cisco 4000	0	0

Broadcaster generating 500 packets per second

<i>Configuration</i>	<i>Packets Dropped</i> <i>(Broadcast Side)</i>	<i>Packets Dropped</i> <i>(Logger Side)</i>
PX-3 to PX-3	2366	0
PX-3 to APX	2366	0
Cisco 4000 to PX-3	0	2366
Cisco 7000 to PX-3	0	2366
Cisco 4000 to Cisco 7000	0	0
Cisco 7000 to Cisco 4000	0	0

Broadcaster generating 600 packets per second

<i>Configuration</i>	<i>Packets Dropped</i> <i>(Broadcast Side)</i>	<i>Packets Dropped</i> <i>(Logger Side)</i>
PX-3 to PX-3	3927	0
PX-3 to APX	3927	0
Cisco 4000 to PX-3	0	3927
Cisco 7000 to PX-3	0	3927
Cisco 4000 to Cisco 7000	0	0
Cisco 7000 to Cisco 4000	0	0

Broadcaster generating 700 packets per second

<i>Configuration</i>	<i>Packets Dropped</i> <i>(Broadcast Side)</i>	<i>Packets Dropped</i> <i>(Logger Side)</i>
PX-3 to PX-3	4722	0
PX-3 to APX	4722	0
Cisco 4000 to PX-3	0	4722
Cisco 7000 to PX-3	0	4722
Cisco 4000 to Cisco 7000	0	0
Cisco 7000 to Cisco 4000	0	0

Broadcaster generating 800 packets per second

<i>Configuration</i>	<i>Packets Dropped (Broadcast Side)</i>	<i>Packets Dropped (Logger Side)</i>
PX-3 to PX-3	5646	0
PX-3 to APX	5646	0
Cisco 4000 to PX-3	623	5023
Cisco 7000 to PX-3	0	5646
Cisco 4000 to Cisco 7000	623	0
Cisco 7000 to Cisco 4000	0	0

Broadcaster generating 900 packets per second

<i>Configuration</i>	<i>Packets Dropped (Broadcast Side)</i>	<i>Packets Dropped (Logger Side)</i>
PX-3 to PX-3	6239	0
PX-3 to APX	6239	0
Cisco 4000 to PX-3	1717	4522
Cisco 7000 to PX-3	276	5963
Cisco 4000 to Cisco 7000	1717	0
Cisco 7000 to Cisco 4000	276	0

7. Performance Test Results (Multipoint - UDP Forwarding)

Due to the limited resources and the overall intention of the testing, we restricted the multipoint tests to the PX platforms. The question to be answered was whether the PX-3 would respond the same way as the point to point test but with various interfaces transmitting broadcast traffic. With two broadcasting spoke sites and a single logger hub site we got the following results:

Broadcaster generating 400 packets per second (aggregate) - one site transmitting at 200 pps and a second site transmitting at 200 pps.

<i>Configuration</i>	<i>Packets Dropped (Broadcast Side)</i>	<i>Packets Dropped (Logger Side)</i>
PX-3 Hub / PX-3 Spokes	0	0
PX-3 Hub/ APX Spokes	0	0
Cisco 4000 to PX-3	Not Tested	Not Tested
Cisco 7000 to PX-3	Not Tested	Not Tested
Cisco 7000 to Cisco 4000	Not Tested	Not Tested

Broadcaster generating 500 packets per second (aggregate) - one site transmitting at 300 pps and a second site transmitting at 200 pps.

<i>Configuration</i>	<i>Packets Dropped (Broadcast Side)</i>	<i>Packets Dropped (Logger Side)</i>
PX-3 Hub / PX-3 Spokes	0	2366
PX-3 Hub/ APX Spokes	0	2366
Cisco 4000 to PX-3	Not Tested	Not Tested
Cisco 7000 to PX-3	Not Tested	Not Tested
Cisco 7000 to Cisco 4000	Not Tested	Not Tested

As expected, the aggregate broadcast traffic at the hub site creates the same results. The total process-switching capacity for the PX platform is limited and independent of the interfaces used.

8. Hybrid Bridge/Router Configuration

One configuration that we were able to test was a hybrid bridge/router configuration. Our testing was restricted to the unclassified portion of the network. In this configuration the two spoke locations bridged the serial and Ethernet interfaces. In the hub location, we utilized bridging on the unclassified interfaces and routing for the serial interface going over to the classified portion of the network. With this configuration we were able to successfully pass an aggregate of 600 pps to the logger off the ethernet interface of the hub node. The same file was broadcast from two different bridge segments, so the total number of PDUs broadcast was 23718 packets.

Broadcaster generating 600 packets per second (aggregate) - one site transmitting at 300 pps and a second site transmitting at 300 pps.

<i>Configuration</i>	<i>Packets Dropped (Broadcast Side)</i>	<i>Packets Dropped (Logger Side)</i>
PX-3 Hub / PX-3 Spokes	0	0
PX-3 Hub/ APX Spokes	0	0
Cisco 4000 to PX-3	Not Tested	Not Tested.
Cisco 7000 to PX-3	Not Tested	Not Tested
Cisco 4000 to Cisco 7000	Not Tested	Not Tested
Cisco 7000 to Cisco 4000	Not Tested	Not Tested

Broadcaster generating 700 packets per second (aggregate) - one site transmitting at 300 pps and a second site transmitting at 400 pps.

<i>Configuration</i>	<i>Packets Dropped (Broadcast Side)</i>	<i>Packets Dropped (Logger Side)</i>
PX-3 Hub / PX-3 Spokes	0	2594 of 23718 sent
PX-3 Hub/ APX Spokes	0	2594 of 23718 sent
Cisco 4000 to PX-3	Not Tested	Not Tested
Cisco 7000 to PX-3	Not Tested	Not Tested
Cisco 4000 to Cisco 7000	Not Tested	Not Tested
Cisco 7000 to Cisco 4000	Not Tested	Not Tested

Further testing must be done to verify the effects on the traffic sent over the serial connection to the classified logger.

9. Conclusions

- The limitations uncovered during the testing involved the level of process switching capacity on the PX-3, the Cisco 4000, and the Cisco 7000.
- The use of UDP - an inherently unreliable transport mechanism - is not always a suitable choice of transport for data that needs a high level of reliability. The transmission control protocol (TCP) is better suited for reliable transport since it uses sequencing and acknowledgments, but at a cost of increased latency - which was not tested. Also, the use of multicasting or unicasting would take advantage of the fast switching capability of all the routers tested.

- The use of broadcast based networking has an adverse effect on the network. Routing this traffic adds one additional layer of processing (especially when the broadcasts are process switched) and creates multiple copies of each datagram in order to forward it to multiple network subnets. Thus, congesting the network with broadcast traffic. Since the key application relies on broadcasts, we should consider flattening the network and use bridging.
- There were definitive “break points” where the processors could not handle anymore packets. This is true on every platform tested.
- During the testing, we did notice that there were drops on the hold-queue, missed buffer requests, and fallbacks on the interface buffers. To remedy this we added to the hold-queue length and increased the number of permanent big buffers. The actual number of successful packets sent never rose above the initial ceiling. In other words, the addition of buffers and increasing the hold-queue did not affect, in any way, the speed at which the processor process-switched the packets. This was expected.
- It is our best judgment, the limitation is with the router’s processor handling UDP broadcasts. With UDP broadcast traffic, all packets are process switched. With unicast and multicast traffic, the router is capable of fast switching most of the packets. Routers gain efficiencies when they are capable of caching routes for packets.
- We had discussions with Technical Assistance Center Staff Engineers from both NET and Cisco Systems over the last two weeks. Engineers from both companies stated that none of their router platforms have ever been tested to find what are the limits of reliable transport of UDP packets.
- The overall configuration relies on the broadcaster. If the network has to reliably transport UDP broadcasts above 400 pps (aggregate) to the hub node to be logged then a PX-3/APX routed solution will not suffice.

10. Recommendations

The initial requirements of the JADS ETE network included a broadcaster transmitting 100 packets per second. All of the configurations tested will satisfy this requirement. Only when the aggregate packet load on the PX-3 (using UDP forwarding) exceeded 400 packets per second was there a concern for lost/dropped packets. With bridging, this ceiling was up to 800 packets per second. If the JADS ETE network is to continue using broadcasted UDP packets with a small number of sites, bridging would be a better solution. Options and limitations are as follows:

Routing

PX-3/APXs - 400 pps aggregate limitation

External Cisco 4000 Routers at each site (serially connected via HSD-2s) - up to 700 pps aggregate limitation; higher cost

Bridging

PX-3/APXs - 800 pps aggregate limitation

Hybrid Routing/Bridging

PX-3/APXs - 600 pps aggregate limitation

Several issues have to be addressed (weighing the pros and cons):

- Broadcasting at lower rates.
 - Pro: Limiting the speed of the broadcasts to under a 400 pps aggregate would ensure the ability to forward all of the UDP traffic through the network.
 - Con: The impact of slower rates on the simulation is unknown.
- The use of multicasting in the future.
 - Pro: The use of multicasting would take advantage of the router's ability to fast switch the traffic. The router only has to process switch the first packet to find the route and will stream the following data along the same route.
 - Con: Finding a suitable data logger may be difficult or a logger would have to be written, and the impact on the simulation is unknown.
- Bridging the entire network.
 - Pro: The use of bridging would increase the reliable throughput of UDP traffic to approximately 800 pps. However, this option should be further tested on the entire JADS ETE network.
 - Con: Speed of transmission is higher, but still limited to 800 pps. Also, it may be difficult to persuade all sites to be part of the same subnet.
- The cost of using external routers.
 - Pro: Different router platforms have different processing power. There are other platforms that have better performance in forwarding UDP packets.
 - Con: There are tangible limitations where the processors could not handle process switched traffic - regardless of platform. Candidate platforms should be tested for this application before procurement. Also, cost is a factor. Costing information is unavailable at this time, but it is safe to state that the more powerful the processor, the higher the cost.

APPENDIX A. ACRONYMS/DEFINITIONS

ADS	Advanced Distributed Simulation
DIS	Distributed Interactive Simulation
DOD	Department of Defense
IP	Internet Protocol: The network layer for the TCP/IP Protocol Suite.
JADS JTF	JOINT ADVANCED DISTRIBUTED SIMULATION JOINT TEST FORCE
JSTARS	Joint Surveillance Targeting and Attack Radar System
LAN	Local Area Network
MAC	Media Access Control: The lower portion of the datalink layer.
MAC-Layer Bridge	A device that connects two or more similar networks in a way that is transparent to the users of the network layer.
OSI	Open Systems Interconnection: The seven layer suite of protocols to be the international standard computer network architecture.
PDU	Protocol Data Unit: An OSI term for "packet." A PDU is a data object exchanged by protocol machines (entities) within a given layer.
PPS	Packets Per Second
T&E	Test and Evaluation
TCP	Transmission Control Protocol: An Internet standard transport protocol in the Internet protocols suite for reliable, connection-oriented, full-duplex streams.
UDP	USER DATAGRAM PROTOCOL: An Internet standard transport protocol that exchanges datagrams without acknowledgments or guaranteed delivery.
WAN	Wide Area Network

All Definitions are from Guide to Networking and Internetworking Terms, Simoneau, Paul, © 1993, American Group, Cary NC

Appendix F

POWERSIM™

The software chosen to develop the simulation of the detailed design of the End-to-End (ETE) Test synthetic environment (SE) is called POWERSIM™, a dynamic simulation tool developed by ModellData AS, Bergen, Norway. Many other software tools exist which may be used to develop simulations of detailed designs. What is important is that the software allow the modeling of all kinds of dynamic processes and be easily adaptable to change, so that variations of the concept may be easily explored. POWERSIM™ allows you to start out with a holistic causal-loop view of a problem and end up with a concise flow diagram model of the same problem, ready to be simulated over time. Figure F-1 is a portion of the graphical diagram of the simulation developed for the entity state protocol data units flow within the JADS ETE SE.

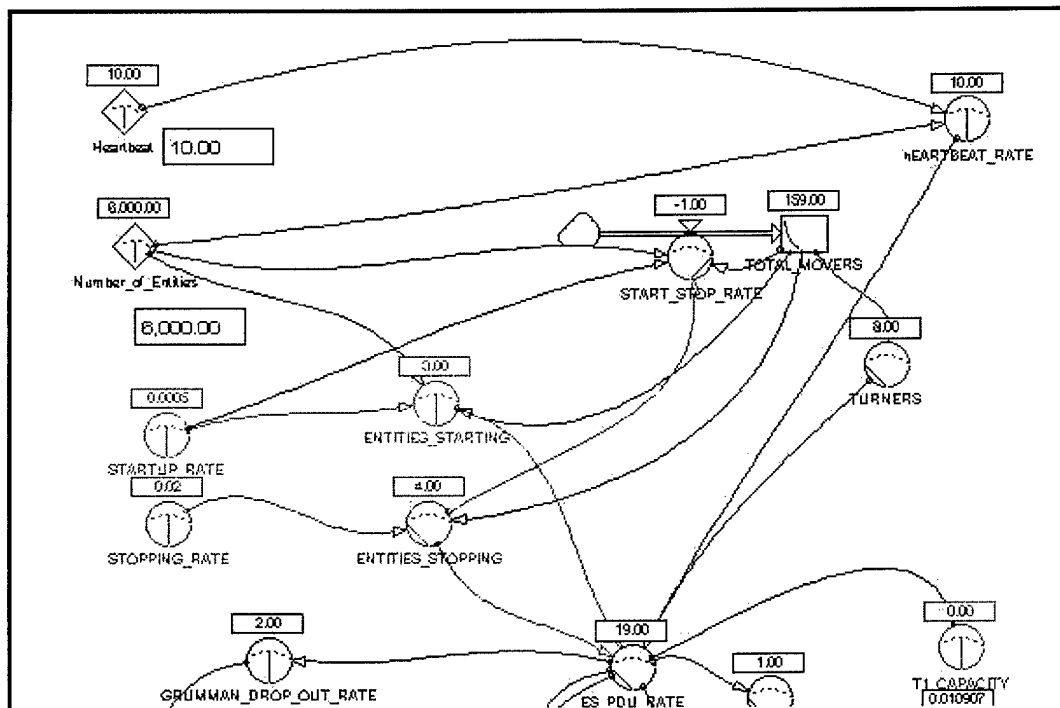


Figure F-1. Graphical Diagram of JADS ETE SE

As can be seen from the graphical diagram, variables, constants, flowrates, and flow variables are used to develop a model of the JADS ETE SE. This simulation can be run over a definable time period, with the final values shown in the small boxes over each element of the model. As each time step is executed, the current values are shown above the model element. The larger boxes beside certain model elements allow for easy changing of constants between simulation runs. All variables, to include flow rates and flow variables, are user definable.

POWERSIM™ also allows the user to use Boolean variables, which can alarm when the value of the variable is false, and allows the plotting of the values of a variable for each time step. This is illustrated in Figure F-2.

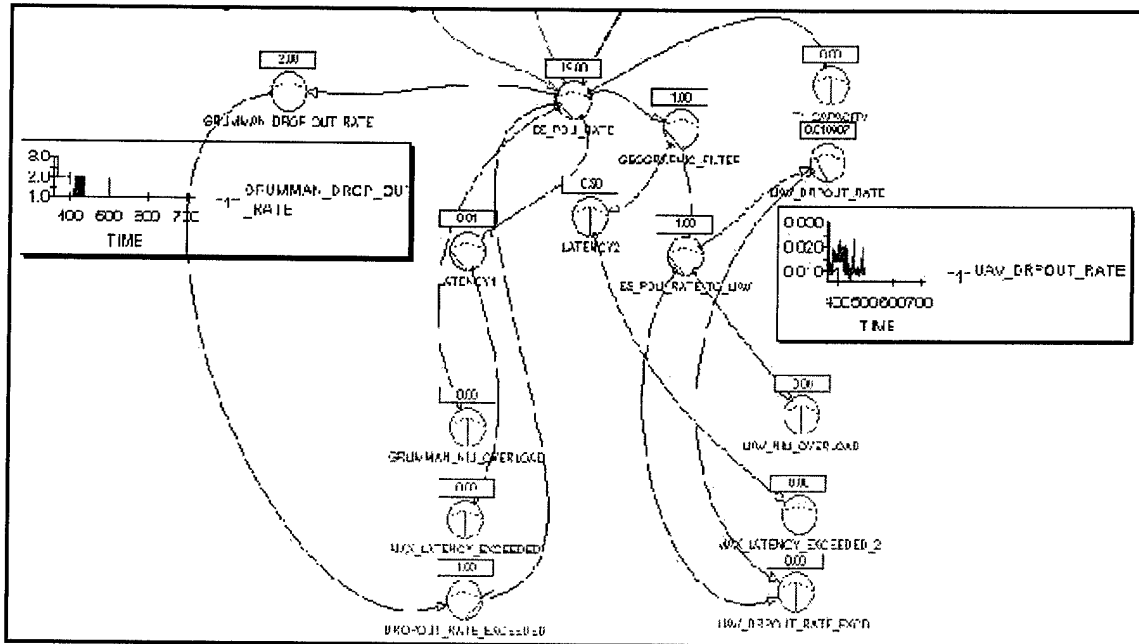


Figure F-2. Graphical Plots of Variable Values

In addition, the values over time of variables within the simulation can be plotted as separate plots available for export to other software packages. This is shown in Figure F-3.

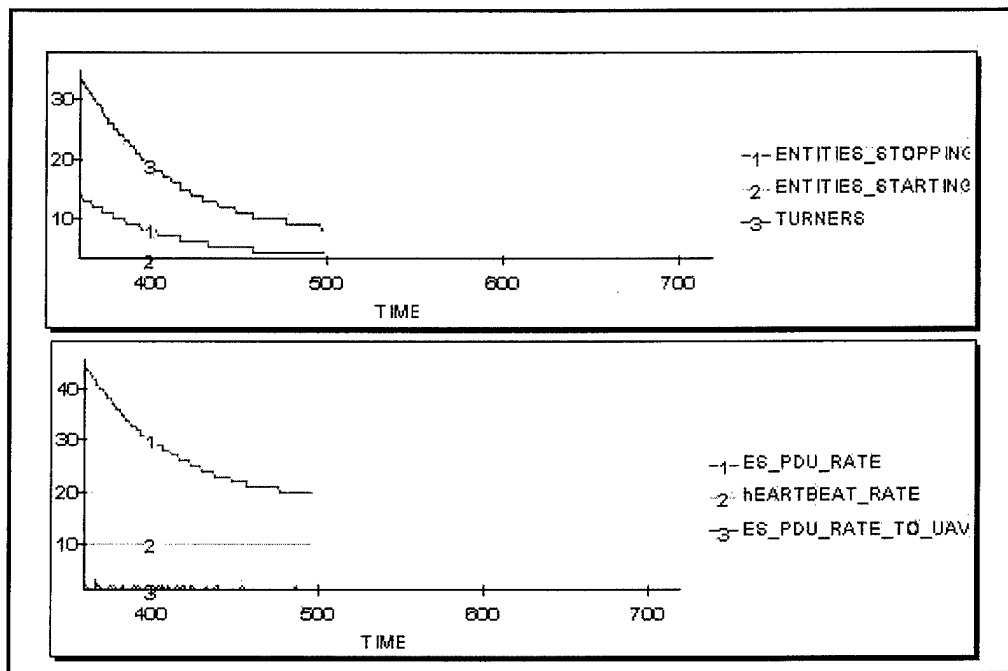


Figure F-3. Variable Plots

Finally, POWERSIM™ allows the values of variables to be displayed in tables, ready for export into other software packages for further analysis. This is shown in Figure F-4.

TIME	TOTAL MOVERS	ES PDU RATE	ENTITIES STOPPING	TURNERS	LATENCY1
359	681.00	46.00	14.00	35.00	0.04
360	670.00	45.00	14.00	34.00	0.04
361	659.00	44.00	14.00	33.00	0.04
362	648.00	44.00	13.00	33.00	0.04
363	638.00	43.00	13.00	32.00	0.04
364	628.00	43.00	13.00	32.00	0.04
365	618.00	42.00	13.00	31.00	0.04
366	608.00	42.00	13.00	31.00	0.04
367	598.00	41.00	12.00	30.00	0.04
368	589.00	41.00	12.00	30.00	0.04
369	580.00	40.00	12.00	29.00	0.03
370	571.00	40.00	12.00	29.00	0.03
371	562.00	40.00	12.00	29.00	0.03

Figure F-4. Variable Tables

Appendix G

Acronyms and Definitions

AC	attack control
ACE	analysis and control element; AMRAAM captive equipment (a pod that simulates an AMRAAM)
ADS	advanced distributed simulation
AOI	area of interest
ARIES	Advanced Radar Imaging Emulation System
ASAS	All Source Analysis System
ATACMS	Army Tactical Missile System
BIU	bus interface unit
CDRL	contract data requirements list
CGS	common ground station; Continental United States ground station
dB	decibel
DIS	distributed interactive simulation
DoD	Department of Defense
ESPDU	entity state protocol data unit
ETE	End-To-End Test
FID	feature identification
GD	graphics display
GDT	ground data terminal
GFE	government furnished equipment
GNIU	ground network interface unit
GRCA	ground reference coverage area
GSM	ground station module
GSMR	Ground Station Module Replicator, Fort Huachuca, Arizona
Hz	hertz
ID	identification
IDNX	Integrated Digital Network Exchange
IEEE	Institute of Electrical and Electronics Engineers
IP	internet protocol; initial point
IPT	integrated product team
JADS	joint advanced distributed simulation or Joint Advanced Distributed Simulation, Albuquerque, New Mexico
Janus	interactive, computer-based simulation of combat operations
Joint STARS	Joint Surveillance Target Attack Radar System
JTF	joint test force or Joint Test Force, Albuquerque, New Mexico
LAN	local area network
LGSM	light ground support module
LWX	local area network/wide area network (LAN/WAN) Exchange
M&S	modeling and simulation
MAC	media access control
MTI	moving target indicator

N&E	network and engineering
NET	network equipment technologies
NIU	network interface unit
OSD	Office of the Secretary of Defense
OSI	open systems interconnection
PDU	protocol data unit
PFA	probability of false alarm
Pg	probability of successful guidance
POWERSIM™	a dynamic simulation developed by ModellDATA AS, Bergen, Norway
PPS	packets per second
PSP	programmable signal processor
PTD	program test design
PTP	program test plan
RDP	radar data processor
RPSI	radar processor simulator and integrator
RSR	radar service request
SAR	synthetic aperture radar
SCDL	surveillance control data link
SE	synthetic environment
SGI	Silicon Graphics, Inc.
SOW	statement of work
STP	software test plan
STR	software trouble report
STRICOM	U.S. Army Simulation, Training, and Instrumentation Command
T&E	test and evaluation
T-1	digital carrier used to transmit a formatted digital signal at 1.544 megabits per second
TAFSM	Tactical Army Fire Support Model
TCAC	Test Control and Analysis Center, Albuquerque, New Mexico
TCP	transmission control protocol
TOA	time of arrival
TRADOC	U.S. Army Training and Doctrine Command
UAV	unmanned aerial vehicle
UDA	user defined activity area
UDP	user datagram protocol
V&V	verification and validation
VSTARS	Virtual Surveillance Target Attack Radar System
VV&A	verification, validation, and accreditation
WAN	wide area network
WSMR	White Sands Missile Range, New Mexico

PHASE 2

VERIFICATION AND VALIDATION REPORT

FOR THE

END-TO-END TEST

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APPENDICES

Appendix A - Janus Suite Price List

Appendix B - Analysis of Janus PDUs

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1.0 Scope

This report provides the results of the verification and validation (V&V) tasks performed during Phase 2 of the End-To-End (ETE) Test

1.1 Purpose

This report details the results of executing the V&V requirements listed within the ETE Test Activity Plan Appendix C, Verification and Validation Plan for the ETE Test and the Phase 2 Verification and Validation Plan for the End-to-End Test.

1.2 Verification and Validation Tasks

The V&V tasks that were performed during the ETE risk reduction test that occurred 7-13 July 1998 are described in the Phase 2 Verification and Validation Plan for the End-to-End Test.

1.3 V&V Process Models

Within this report reference is made to steps enumerated within the Distributed Interactive Simulation (DIS) Nine Step Process Model. This model is shown below as Figure 1.

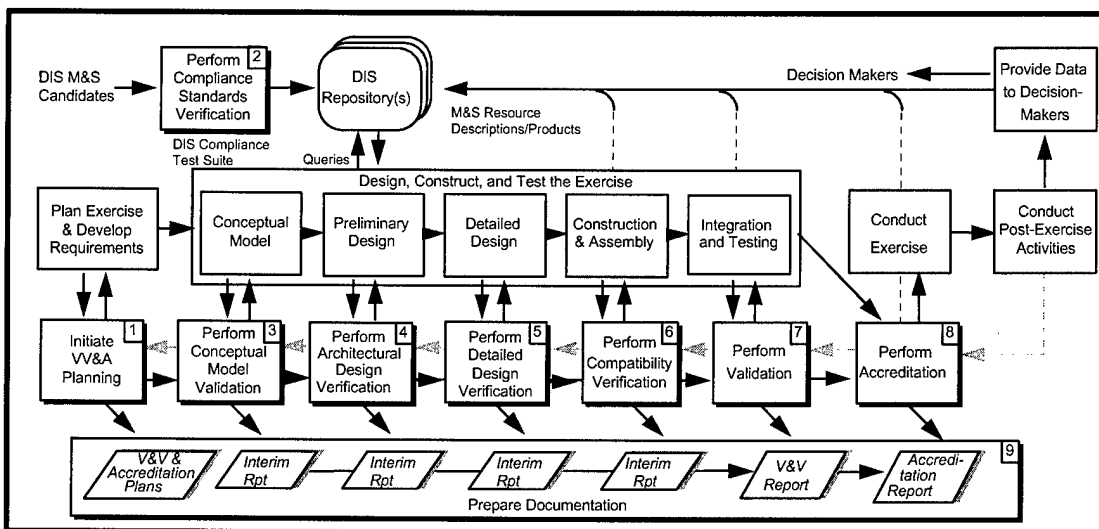


Figure 1. DIS Nine Step VV&A Process Model

The process model and its accompanying *Recommended Practice for Distributed Interactive Simulation -- Verification, Validation, and Accreditation* (Draft-4 November 1996) form the basis for the verification, validation and accreditation (VV&A) of the ETE Test synthetic environment (SE).

The DIS Nine Step Process Model was developed with a conventional, short-lived, DIS exercise in mind, as opposed to a test of a major system, and presupposes a full complement of funds and personnel available at the beginning of the exercise development. This disparity was brought to the attention of the developers of the DIS Nine Step Process Model, and the conclusion was reached that since the model was recommended and intended for tailoring to the needs of the user, the model would continue to be tied to the DIS exercise development and construction process contained within Institute of Electrical and Electronics Engineers (IEEE) Standard 1278.3.

If one tailors the DIS Nine Step Process Model to the joint test process, then the process model would appear as shown in Figure 2.

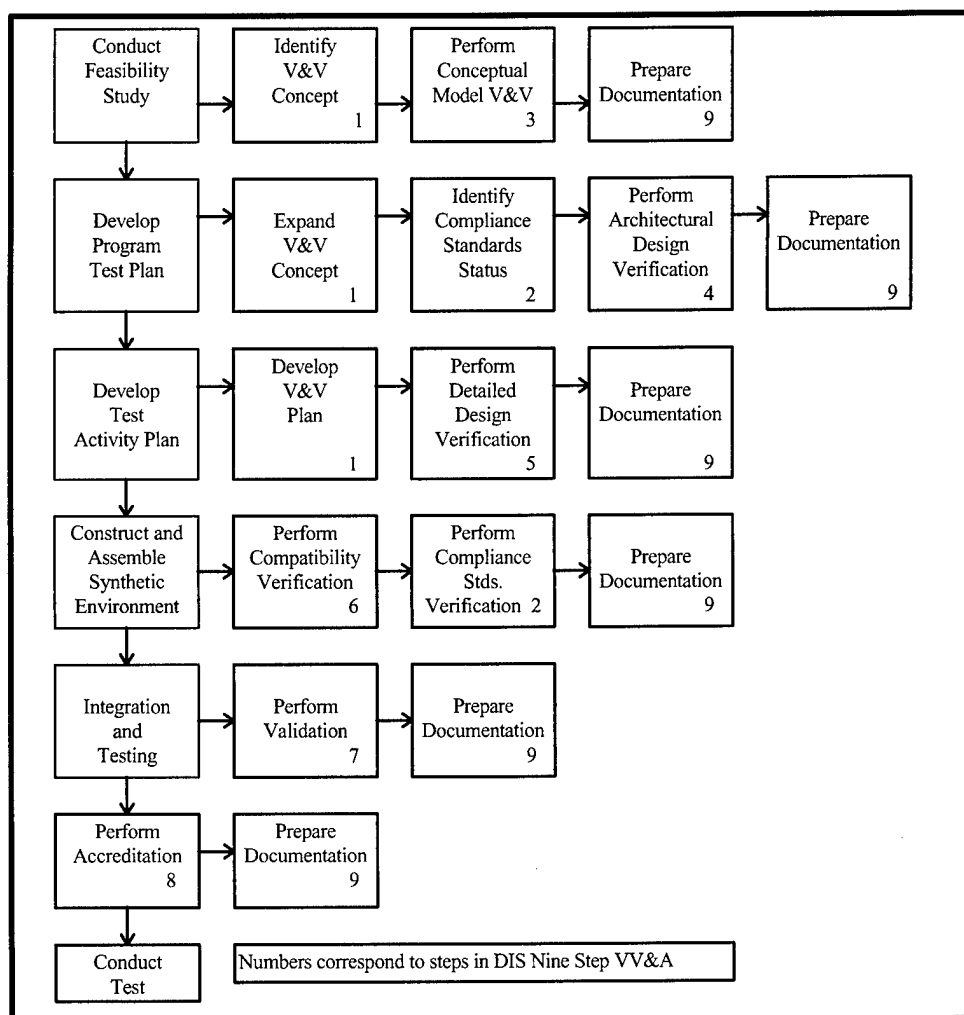


Figure 2. JADS ETE Test Process Model

In the JADS ETE Test Process Model, test events, which consist of the planning, construction and assembling of the SE, integration and testing of the SE, accreditation of the SE, and conduct of the test all proceed on the left side from top to bottom. The V&V events, to include documentation, proceed to the right for each test event.

2. Applicable Documents

2.1 Documents

ETE Test Activity Plan Appendix C: Verification and Validation Plan for the End-To-End (ETE) Test

Phase 2 Verification and Validation Plan for the End-to-End Test.

Department of Defense Verification, Validation and Accreditation (VV&A) Recommended Practices Guide, November 1996

Recommended Practice for Distributed Interactive Simulation -- Verification, Validation, and Accreditation, 4 November 1996

3. Verification and Validation Tools

The following nonstandard software were used in the ETE Test Phase 2 V&V:

JADS Toolbox

JADS Logger

U.S. Army Simulation, Training and Instrumentation Command (STRICOM) Logger

4. Verification Tasks

This section of the Phase 2 V & V results states the verification requirements and describes the results of performing the procedures as stated in the Phase 2 Verification and Validation Plan for the End-to-End Test.

4.1 Janus V6882

4.1.1 Verify Simulation

Verify that Janus V6882 is capable of simulating at least 5000 entities with at least twenty-five percent moving using a commercial off-the-shelf (COTS) product costing less than \$100,000.

4.1.1.1 Procedure

The ETE Test U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC), White Sands Missile Range (WSMR), New Mexico, site representative performed the following procedures:

- a) Using the Force editor contained within Janus, verify that each scenario to be used for the ETE Phase 2 operational test (OT) contains at least 5000 entities.
- b) While the scenario(s) is running, verify that at least 1250 entities move during the course of the scenario. (Note: Not all vignettes used during the ETE Phase 2 OT call for at least 1250 moving entities)
- c) Determine the cost of the COTS product used to run the above scenarios.

4.1.1.2 Results

- a) ETE Test event logs maintained by the ETE Test TRAC-WSMR site representative contain the following entries:
 - Date: 7 Jul 98 Time: 1310Z Vignette 1/Scenario 901/9897 entities
 - Date: 8 Jul 98 Time: 1256Z Vignette 1/Scenario 901/9897 entities
 - Date: 9 Jul 98 Time: 1300Z Vignette 2/Scenario 902/9757 entities
 - Date: 10 Jul 98 Time: 1306Z Vignette 3/Scenario 903/9904 entities
 - Date: 13 Jul 98 Time: 1255Z Vignette 3/Scenario 903/9904 entities
- b) ETE Test event logs maintained by the ETE Test TRAC-WSMR site representative contain the following entries:
 - Date: 7 Jul 98 Time: 2054Z Vignette 1 Scenario 901 Logfile analysis/1639 separate entities moved/max of 601 entities moving at one time.
 - Date: 13 Jul 98 Time: 2028Z Vignette 3 Scenario 903 Logfile analysis/4591 separate entities moved/max of 3268 entities moving at one time.
- c) Price list for suite of equipment required to run Janus as the Virtual Surveillance Target Attack Radar System (VSTARS) stimulator is contained in Appendix A. Total estimate for suite is \$19,800.

4.1.2 Verify Issue of Protocol Data Units

Verify that Janus V6882 issues distributed interactive simulation (DIS) 2.0.4 entity state protocol data units (ESPDU) that conform in content and format with the DIS 2.0.4 standards as amended by JADS.

4.1.2.1 Procedure

- a) Test Control and Analysis Center (TCAC) personnel monitored the ESPDUs arriving from the Janus computer at TRAC-WSMR using the JADS toolbox. The type of protocol data units (PDU) issued by Janus were noted in the TCAC log.
- b) Following the ETE risk reduction test, the ESPDUs broadcast by Janus were analyzed to determine that the content of the ESPDUs conforms with the DIS 2.0.4 standards as amended by JADS ETE Test.

4.1.2.2 Results

- a) ETE Test event logs maintained by TCAC site representative contain the following entries:
 - Date: 7 Jul 98 Time: 1326Z: Run number from WSMR - 901-01
 - Date: 7 Jul 98 Time: 1326Z: Start loggers, Start Janus
 - Date: 7 Jul 98 Time: 1330Z: TCAC sees PDUs
 - Date: 7 Jul 98 Time: 1331Z: Confirm ESPDUs
 - Date: 8 Jul 98 Time: 1311Z: Run number 901 01 from WSMR
 - Date: 8 Jul 98 Time: 1315Z: Janus started TCAC sees PDUs
 - Date: 8 Jul 98 Time: 1316Z: Confirm ESPDUs
- b) Following the ETE risk reduction test, the log files of the ESPDUs broadcast by Janus were analyzed and found to conform with the DIS 2.0.4 standards as amended by JADS ETE Test. Representative analyses are contained within Appendix B.

The DIS standard requires that for an ESPDU, the "... timestamp shall be specified using a 32-bit unsigned integer representing units of time passed since the beginning of the current hour. The least significant bit shall indicate whether the timestamp is absolute or relative." Because the ETE test vignettes used in Janus involve nearly ten thousand entities and run for nearly seven hours, it was necessary to modify the standard and represent time as a 32-bit unsigned integer representing milliseconds since the beginning of the vignette (relative timestamp). This allows the tester to trace an ESPDU back to a discrete event that occurred within the Janus vignette. This is a common practice in most DIS synthetic environments (SE) that exist for periods greater than one hour.

4.1.3 Verify Receipt and Action of Protocol Data Units

Verify that Janus V6882 will receive and act upon each ESPDU, fire PDU, and detonate PDU issued to it by the network and will take the appropriate action as dictated by the PDU, provided the appropriate data sets regarding the PDU have been entered into the simulation.

4.1.3.1 Procedures

The ETE Test TRAC-WSMR site representative performed the following procedures:

- a) Verify, by observing the Janus monitor, that ESPDUs received from other nodes within the SE are displayed correctly, provided they are located within the Janus scenario area. The Fort Sill, Oklahoma, site representative provided a list of entities represented within the Tactical Army Fire Support Model (TAFSM) and their locations to the TCAC for dissemination to the other nodes within the SE.
- b) Verify, by observing the Janus monitor, that fire and detonate PDUs are correctly handled by Janus. Fort Sill site representatives notified the Janus site representative of the predicted impact point before each Army Tactical Missile System (ATACMS) was fired. In addition, they notified the Janus site representative when the shot was fired (fire PDU) and when it detonated (detonate PDU). The Janus site representative made an entry in the log file when the detonate PDU was received, as well as a numbered count for each, and also recorded additional information describing the 'killed' entities.

4.1.3.2 Results

- a) Appendix C: Section C1 contains the results of observing the Janus monitor. Janus correctly identified all Fort Sill entities as being outside the scenario terrain box. Appendix C: Section C2 contains the location of all Fort Sill entities as supplied by TAFSM.
- b) Appendix C: Section C3 contains the ETE Test event logs for TRAC-WSMR. These logs show the results of the detonate PDUs transmitted by Fort Sill. Fire PDUs are not recorded as the entities firing are outside the scenario terrain box and Janus does not track them. Additional information regarding the 'killed' entities is also contained within the ETE Test event logs.

4.1.4 Verify Acceptance and Processing of Scenarios

Verify that the simulation will accept and process scenarios with a duration longer than eight hours.

4.1.4.1 Procedures

The Janus site representative noted in the site log file the duration of each scenario during the ETE risk reduction test.

4.1.4.2 Results

ETE test event logs maintained by the ETE Test TRAC-WSMR site representative contain the following entries:

- Date: 7 Jul 98 Time: 2032Z Vignette 1/Scenario 901 Janus game time 08:00:46
- Date 8 Jul 98 Time: 2006Z Vignette 1/ Scenario 901 Janus froze up - game time 7:17:25

- Date: 9 Jul 98 Time: 1337Z Vignette 2/Scenario 902 Stop Janus - game time 1:21 (Advanced Field Artillery Tactical Data System [AFATDS] at Fort Hood did not have ATACMS launcher data for Scenario 902)
- Date: 9 Jul 98 Time: 2002Z Vignette 1/Scenario 901 Stop Janus - game time 7:10:40
- Date: 10 Jul 98 Time: 2020Z Vignette 3/Scenario 903 Stop Janus - game time 7:00:30 (Scenario 903 only seven hour scenario)
- Date: 13 Jul 98 Time: 2010Z Vignette 3/Scenario 903 Stop Janus - game time 7:00 (Scenario 903 only seven hour scenario)

4.1.5 Verify Interaction With Scenario

Verify that the operator will be capable of fully interacting with a scenario while it is running.

4.1.5.1 Procedure

The Janus site representative interacted with the scenario after several ATACMS impacts by altering the behavior of the surviving entities within the immediate area of the impact. A log entry was made after each interaction indicating the results of the interaction.

4.1.5.2 Results

ATACMS missiles were only fired on the last three test days (070998,071098,071398) and difficulty was experienced the first day in determining target locations. As a result, no displacements of enemy forces were performed as a result of ATACMS missions fired on 070998. ETE Test event logs maintained by the ETE Test TRAC-WSMR site representative contain the following entries:

- Date: 10 Jul 98 Time: 1640Z Vignette 3/Scenario 903 Finished interactive move of 31 entities from 5th Corps Headquarters (HQ)
- Date: 10 Jul 98 Time: 1838Z Vignette 3/Scenario 903 Finished interactive move of 504th Supply and Transportation Battalion and 407th Air Defense Artillery Brigade HQ
- Date: 13 Jul 98 Time: 1540Z Vignette 3/Scenario 903 Finished interactive move of vehicles around road intersection that was site of detonation

4.1.6 Verify Simulation Capability to Proceed in a Steplike Fashion

Verify that the simulation will be capable, when running, of proceeding in a steplike fashion at a pace representative of near real time. That is, when a unit of game time is represented within Janus a corresponding amount of time will have elapsed since the start of the simulation. This feature will be adjusted by tuning the scenario.

4.1.6.1 Procedure

The Janus site representative observed the clock time when Janus started and noted it in the site log. The elapsed time since the start of Janus was observed periodically (approximately every 30 minutes and compared to the elapsed game time. These times were noted in the site log.

4.1.6.2 Results

ETE Test event logs maintained by the ETE Test TRAC-WSMR site representative contain the following representative entries:

- Date: 7 Jul 98 Time: 1331Z Vignette 1/Scenario 901 Start Janus DIS at 59:59/13:30:50Z (Offset equal to 12:30:51)
- Date: 7 Jul 98 Time: 1602Z Vignette 1/Scenario 901 Janus 3:31/ 16:01:47Z (Offset equal to 12:30:47)
- Date: 7 Jul 98 Time: 1934Z Vignette 1/Scenario 901 Janus 06:30/ 19:00:47Z (Offset equal to 12:30:47)
- Date: 13 Jul 98 Time: 1310Z Vignette 3/Scenario 903 Start Janus 0:00/13:10:00Z (Offset equal to 13:10:00)
- Date: 13 Jul 98 Time: 1621Z Vignette 3/Scenario 903 Janus 3:10:59/16:21:04Z (Offset equal to 13:10:05)
- Date: 13 Jul 98 Time: 1840Z Vignette 3/Scenario 903 Janus 5:30:00/18:40:04Z (Offset equal to 13:10:04)

4.1.7 Verify Capability of Using Scenarios

Verify that the simulation will be capable of utilizing scenarios conducted upon terrain representing a simulation area of at least 200 kilometers (km) by 200 km.

4.1.7.1 Procedure

Prior to the start of each scenario, the Janus site representative determined the coordinates of each corner of the Janus terrain box and noted them in the site log.

4.1.7.2 Results

ETE Test event logs maintained by the ETE Test TRAC-WSMR site representative contain the following entries:

- a) Date: 7 Jul 98 Time: 1315Z Vignette 1/Scenario 901 Terrain:
- Upper Left 31° 32' 34" N 45° 28' 39" E
 - Lower Left 30° 00' 47" N 45° 28' 12" E
 - Upper Right 31° 31' 25" N 47° 15' 41" E
 - Lower Right 29° 59' 42" N 47° 13' 34" E

Result is a terrain box 170 km by 170 km

b) Date: 10 Jul 98 Time: 1309Z Vignette 3/Scenario 903 Terrain:

- Upper Left 31° 48' 54" N 45° 28' 38" E
- Lower Left 30° 16' 56" N 45° 18' 10" E
- Upper Right 31° 47' 45" N 47° 16' 12" E
- Lower Right 30° 15' 51" N 47° 14' 02" E

Result is a terrain box 170 km by 170 km

4.2 Tactical Army Fire Support Model

4.2.1 Verify Acceptance of Artillery Missions

Verify that TAFSM will accept artillery missions using tactical fire (TACFIRE) or Advanced Field Artillery Tactical Data System (AFATDS) messages encapsulated in a DIS PDU. Simulation will issue a fire and detonate PDU whenever an ATACMS missile is fired and subsequently detonated.

4.2.1.1 Procedure

The Fort Sill site representative noted in the site log when each artillery mission was received by TAFSM via a DIS PDU. The site representative subsequently noted when the fire and detonate PDUs corresponding to the artillery mission were issued. This information was provided by a post-test history file and observer log sheets.

4.2.1.2 Results

During the first functionality and integration test, the decision was made by the ETE Test manager to modify the design of the ETE Test SE. The modification consisted of having the AFATDS located at Fort Hood communicate directly with the AFATDS at Fort Sill. This communication would be accomplished using standard AFATDS message traffic instead of DIS PDUs. The AFATDS at Fort Sill would then communicate with a network interface unit, called a personal computer network interface unit (PCNIU), which would pass the AFATDS traffic to TAFSM using signal and transmitter PDUs. After TAFSM processes the fire mission sent to it by AFATDS, TAFSM then broadcasts a fire PDU when the ATACMS missile is launched and a detonate PDU when the missile impacts.

The DIS logger located at Fort Sill only records DIS PDUs. AFATDS traffic is recorded by the AFATDS devices at each location. An example of AFATDS traffic is included as Appendix D: Section D1.

A record of the DIS PDUs generated by Fort Sill is included as Appendix D: Section D2. As can be seen, signal, transmitter, fire, and detonate PDUs are generated by Fort Hood.

Finally, the site event logs are included as Appendix D: Section D3.

4.3 End-To-End Test Synthetic Environment

4.3.1 Perform Compliance Standards Verification (Step 2)

Compliance standards verification will be performed after the ETE Risk Reduction Test and will consist of an inspection of a sampling of PDUs emitted by each simulation to insure proper adherence to the prescribed format. In addition, a model interface analysis of the SE will be conducted to determine if the submodels within the SE are correctly communicating using DIS PDUs.

4.3.1.1 Procedures

- a) Following the ETE risk reduction test, the TCAC PDU log file for each day was randomly sampled to ensure proper adherence to the prescribed format. Sample size was at least 100 PDUs, where possible, from each simulation generating PDUs.
- b) Within the ETE Test SE as developed for the OT, there are two instances of submodels communicating using DIS PDUs. These instances are the transfer of ESPDUs from Janus to the Virtual Surveillance Target Attack Radar System (VSTARS) and the transfer of fire and detonate PDUs from TAFSM to Janus. The PDU log files taken at the above nodes were compared post test to determine how reliably the simulations communicated amongst themselves.

4.3.1.2 Results

- a) The PDU log files for each test day were analyzed using the JADS Toolbox. Data extracted from the log files verified that the simulations broadcasting PDUs within the ETE Test SE adhered to the prescribed format. Appendix B contains a representative analysis file of ESPDUs broadcast by Janus at TRAC-WSMR on 13 July 1998.
- b) An analysis of how well two simulations communicate between themselves involves two states. Either the network connecting the simulations is in a normal state and communication occurs, or the network is down and no communication occurs. This verification task will consider only the normal state of the network, when communication occurs. Network outages, when no communication occurs, will be discussed at a later verification step.

During the five days of testing, more than a million and a half ESPDUs were broadcast from Janus and received by VSTARS. In an attempt to reduce these data to a more manageable amount, each test day was divided into one-hour periods and then samples of 16000 contiguous ESPDUs were selected on a random basis. These samples were then compared between the two sites and

the number of PDUs dropped during normal network operation was observed. Appendix E contains a portion of one of the comparison files with the results shown.

Overall, out of 96000 PDUs compared, only 30 were lost in transmission, which would indicate that the communication between Janus and VSTARS is highly reliable when the network is operating normally. Further analysis of overall network performance will be discussed later in this report.

The transfer of fire and detonate PDUs between Fort Sill and TRAC-WSMR was without error during the three days of testing when ATACMS missiles were fired. Appendix E: Section E3 contains the comparison file for 13 July 1998.

4.3.2 Perform Capability Verification (Step 6)

The compatibility verification will be performed by the ETE tTest V&V team during Phase 2 of the ETE Test. The compatibility verification will complete the verification of the ETE Test SE by ensuring

- a) modeling and simulation (M&S) components exchange data and interact appropriately with each other;
- b) individual components correctly use the common data (e.g., terrain, weather) to generate their portion of the synthetic environment; and
- c) the overall implementation is adequate to address the exercise requirements.

This activity involves five major tasks: Evaluate design versus implementation, evaluate compatibility, evaluate interface implementation, assess instrumentation requirements, and evaluate impact of operator proficiency.

Evaluate Design Versus Implementation: This task will determine if the design is sufficient to ensure the adequacy of the overall implementation by comparing the design as documented (e.g., conceptual model, component compliance profiles and fidelity characterizations) and the exercise configuration. The V&V team will participate in an exercise development walk-through and apply a series of checks to compare the physical configuration to the documented design. In addition, functional testing will be applied to assess performance of the SE over the course of the test.

Evaluate Compatibility: This task will determine if the individual components

- a) represent system performance as required for the exercise;
- b) transfer information to and from the network without corruption;
- c) share common perspectives of the virtual reality produced by the exercise; and
- d) employ database elements, shared models and support systems appropriately.

Evaluate Interface Implementation: This task focuses on network performance needs, interface implementation issues, and identification of changes in the exercise configuration that

could impact operation of the network. The V&V team will inspect the hardware configuration and review data collection and transfer (e.g., PDUs) among components to determine if the interface implementation is in accordance with interface specifications. The V&V team will also evaluate the results of network loading and latency tests for possible impacts on simulation results.

Assess Instrumentation Requirements: The V&V team will evaluate the adequacy of the instrumentation requirements for V&V purposes.

Evaluate Impact of Operator Proficiency: The V&V team, in association with identified subject matter experts (SMEs), will observe and evaluate the performance of operators to determine if they possess the appropriate skill level to perform the functions required for the test.

4.3.2.1 Procedures

- a) **Evaluate Design Versus Implementation:** This task has been performed over the course of the last four functionality and integration tests. Following the ETE risk reduction test the V&V team reviewed the overall implementation of the test and compared it to the documented design. Both compliance with the documented design and functionality were addressed. The report on this task will address not only deviations from the documented design but also the impact of the deviation upon the functionality of the SE, if any.
- b) **Evaluate Compatibility:** This task has been performed over the course of the last four functionality and integration tests. Following the ETE risk reduction test the V&V team evaluated the compatibility of the individual components. The report on this task addresses areas of incompatibility, their impact upon the SE, and projected fixes, if any.
- c) **Evaluate Interface Implementation:** This task was performed by the V&V team following the ETE risk reduction test using data collected during the test. The report on this task addresses performance and possible impacts on simulation results.
- d) **Assess Instrumentation Requirements:** This task was performed by the V&V team following the ETE risk reduction test. It consisted of a review of data collected and instrumentation present during the test. The report on this task addressed V&V areas that are impacted by lack of instrumentation and the extent of the impact upon V&V.
- e) **Evaluate Impact of Operator Proficiency:** For the system under test (the Joint Surveillance Target Attack Radar System [Joint STARS]) this V&V task is impacted by the fact that the operators are generally the SMEs. The operators can be divided into two groups, those associated with the E-8C and those associated with the light ground support module (LGSM). All E-8C operators are required to be certified annually as to their proficiency in performing their assigned tasks. All operators used in the risk reduction test were evaluated during the conduct of the test. The report on this task addresses operator efficiency and its impact upon the OT.

4.3.2.2 Results

- a) **Evaluate Design Versus Implementation:** As mention previously, during the first functionality and integration test the decision was made by the ETE Test manager to modify the design of the ETE Test SE. The modification consisted of having the AFATDS located at Fort Hood communicate directly with the AFATDS at Fort Sill. This communication would be accomplished using standard AFATDS message traffic instead of DIS PDUs. The AFATDS at Fort Sill would then communicate with a network interface unit, called a PCNIU, which would pass the AFATDS traffic to TAFSM using signal and transmitter PDUs. After TAFSM processes the fire mission sent to it by AFATDS, TAFSM then broadcasts a fire PDU when the ATACMS missile is launched and a detonate PDU when the missile impacts.

The remainder of the SE remains as developed during the detailed design and described within the ETE Test Activity Plan Appendix C: Verification and Validation Plan for the End-To-End (ETE) Test. Basically, the remainder of the SE consists of a scenario generator or wargame, Janus; an E-8C simulation, VSTARS; an actual LGSM at Fort Hood, which receives radar reports from VSTARS; and a target analysis cell (TAC) that issues ATACMS fire missions through AFATDS. The TAC is a subset of the corps analysis control element (ACE). Once TAFSM issues the fire and detonate PDUs described above, Janus calculates the effects of the missile shot and the end-to-end loop begins again with Janus transmitting the results to VSTARS.

The deviation from the documented design described above was in actuality a simplification of the design. The changing of an AFATDS message generated at Fort Hood into a DIS PDU for transmission to another AFATDS located at Fort Sill, with the resultant changing of the PDU back to the AFATDS message, was a needless complication and a potential source of error within the SE. Use of the system's means of communication also added validity to the SE, as any problems or errors experienced were real errors as opposed to errors caused by advanced distributed simulation (ADS).

The functionality of the SE design is documented by observer logs and analysis of simulation and PDU log files, as previously discussed. The true functionality of the SE is best described, however, by a statement made by one of the members of the TAC. He stated that this was the first time to his knowledge that the TAC was able to perform its assigned mission under tactical conditions in a doctrinally correct manner with all systems performing as designed.

- b) **Evaluate Compatibility:** All ADS elements of the SE were compatible with each other to the degree required. This is not a surprising result as all elements were either designed and built to be compatible or were modified to be compatible over the course of the conduct of four functionality and integration tests.

This was not the case with the fielded real systems used within the SE. There were many incompatibility problems among these fielded systems that persisted well into the ETE risk reduction test. As stated earlier, the TAC had never had the opportunity to perform this

function, under tactical conditions in a doctrinally correct manner prior to the ETE risk reduction test.

- c) **Evaluate Interface Implementation:** This portion of the V&V considers the technical performance of the SE and the interfaces and networking equipment involved in supporting the SE.

Appendix F contains the ETE Test risk reduction 1 analysis summary. In summary, the SE was fully available 96.49% of the time for testing. During the period (2 hours 37 minutes) the JADS ground data terminal 1553 bus interface unit was down, testing could still be conducted at the VSTARS node. This left only two minutes, out of a total of 35 hours 7 minutes, that the SE was unavailable for testing of any kind.

- d) **Assess Instrumentation Requirements:** No additional instrumentation requirements for the ETE Test were identified during the ETE risk reduction test. All technical measures could be evaluated using data collected with existing instrumentation. Operational measures were evaluated using observer logs combined with simulation or system history tapes.

This is not to say that additional instrumentation could not be added to support a different test design. As an example, the unclassified portion of the ETE Test network is not instrumented with Spectrum™ to measure bandwidth utilization, since it must be by design equal to or less than the bandwidth utilization on the classified side. If used for a different test design, this may not be the case and the unclassified portion of the ETE Test network would need to be instrumented for the measurement of bandwidth utilization. This point is brought out to emphasize that this V&V directly applies only to the ETE Test SE.

- e) **Evaluate Impact of Operator Proficiency:** The impact of operator proficiency is very high for the ETE Test. Even though all operators are 'trained' in the operation of their systems, both the Army and Air Force have acknowledged that their existing training systems leave a lot to be desired. In fact, both services have expressed a desire to utilize VSTARS in future training systems.

In addition to the absence of effective training systems, peacetime training missions do not expose the operators to many of the tasks and functions they are expected to perform during hostilities. As a result, during the conduct of the modified Turing test one of the test subjects, a 'trained operator,' remarked that during the test he had the opportunity to perform a certain function for the first time in the three years he had been assigned to the system. Additionally, during the modified Turing test another operator asked for a Joint STARS Operators Manual, because he was asked to do things that he did not normally have the opportunity to do. With the manual he was able to successfully accomplish the task.

The end result of all of this is that even though no additional training is required to use the SE, the operators must use the SE to learn or practice the tasks they are expected to perform using the real system. This is a result of the fact that to date only the SE and war places the system and the operator in an operationally realistic environment.

As a result, the functionality and integration tests and the risk reduction test have been not only tests and rehearsals but also training sessions for the operators. Are they trained sufficiently well so as to participate effectively in the test? A difficult question to answer, as there is no way to test them without using the SE. At best, we can only say that they are better trained then when we started and they can successfully execute the requirements of the test using the SE.

5. Validation Tasks

5.1 Janus V6882

5.1.1 Validate That Janus Represents Vehicle Behavior

Validate that Janus V6882 represents vehicle behavior to the degree detectable by the Joint STARS. This capability will be judged based upon viewing vehicle movement upon the Joint STARS operator workstation. Joint STARS operator SMEs will be used to evaluate these criteria.

5.1.1.1 Procedures

- a) During the ETE risk reduction test, operators at both Northrop Grumman, Melbourne, Florida, and Fort Hood, Texas, were queried as to whether or not the vehicle movement seen on the workstation monitors appeared realistic. If it was considered unrealistic, the operators were asked what impact this had on the performance of their assigned tasks. Their responses became a part of the site log file and were reviewed post test by the ETE Test V&V team.
- b) In addition, the TRAC-WSMR PDU log files were analyzed post test and reviewed to ensure that Janus V6882 properly represents vehicle movement.

5.1.1.2 Results

- a) Observation of workstation monitors by members of the V&V team and reports from operators during the risk reduction test revealed instances of unrealistic vehicle movement under certain scenario conditions. The anomaly manifested itself by having portions of convoys missing turns and wandering off into the desert. The lost portions of the convoys would then jump back into formation after a period of time and resume normal movement. Another manifestation of the anomaly had elements of a convoy miss a turn and proceed to cross the Euphrates River without benefit of a bridge. As an aside, the operator automatically verified that a bridge did not exist by taking a virtual synthetic aperture radar (SAR) image of the crossing site. Logs of the observers who worked with the operators are included as Appendix F.

Visual analysis of the moving target indicator (MTI) radar reports by ETE Test V&V team members led them to the conclusion that VSTARS was not receiving change of state ESPDUs from the Janus simulation located at TRAC-WSMR. VSTARS will dead reckon an entity based on the last PDU received until a new PDU is received. A quick check with the TCAC revealed that the network was functioning normally and that VSTARS was receiving all PDUs broadcast by Janus.

Measurement of the time differential between when the entities began to wander off and when they leaped back into formation led the ETE Test V&V team members to believe that the anomaly was related to the heartbeat period used for the scenario. Further observation revealed that the anomaly only occurred during periods of heavy scenario activity. As an example, at the time the anomaly was observed, the scenario (Scenario 903) contained nearly 10,000 entities with more than 3000 of the entities moving. The anomaly was not observed when simpler, less busy scenarios (Scenario 901) were run.

For clarification it is necessary to state that Janus, like the majority of DIS-compliant simulations, broadcasts two types of ESPDUs. Change of state ESPDUs are a result of an entity starting, stopping, turning or changing speed beyond preset limits. They are also referred to as dead-reckoning PDUs and are broadcast whenever the entity meets the change of state condition. Heartbeat ESPDUs are broadcast at a preset rate for all entities that have not experienced a change of state during the heartbeat period.

As an example, for a 10000 entity scenario with no entities moving and a heartbeat period of 10 minutes, an observer would see 10000 ESPDUs broadcast over a ten minute period in entity order. Once entities started moving, however, an observer would expect to see more than 10000 PDUs broadcast and they would not be in entity order. The extra PDUs are a result of a change in state after the heartbeat PDU for that entity has already been broadcast or multiple changes of state during the 10 minute heartbeat period.

Obviously, an anomaly of this type will have a major impact on the performance of the operators' tasks. Fortunately, this anomaly occurs only under certain conditions and solutions are potentially available.

- b) Post-test analysis of the ESPDU log files revealed that what the ETE Test V&V team suspected was true. The rate at which heartbeat ESPDUs are broadcast and the heartbeat period must be set before the scenario is executed in Janus. A low rate is desired because the information contained in the ESPDU will be sent to the E-8C by satellite communication (SATCOM), and the network routers start to drop increasing numbers of PDUs as the rate increases. The heartbeat period is set based on the rate and the number of entities within the scenario. Previous practice was to set the heartbeat period very close to the minimum required for the rate used in the simulation run.

This worked fine until more than entities started moving all over the landscape. At this point, Janus simply could not do everything in the time allocated and failed to send a PDU for each entity within the scenario for a specified heartbeat period. Instead, it would start the next

heartbeat period and, depending upon the load during that period, correct the location of the lost entities or fall even farther behind. For those entities that were stationary, this made no difference. The omitted change of state PDUs for entities turning, however, resulted in the entities wandering off into the desert.

5.1.1.3 Solutions

There are three immediately available solutions to the problem just described that do not require any modifications to Janus. Unfortunately, the problem occurred and was identified during the last two hours of the last day of the risk reduction test. A full check-out of any solution will have to wait until the SE is reestablished during the rehearsal and test preparation period prior to the ETE operational test. The possible solutions are

- a) Increase the rate at which Janus issues heartbeat PDUs to the maximum allowed by network constraints and increase the heartbeat period to the maximum allowed. This will allow Janus to issue PDUs at a faster rate and will allow Janus more time to accomplish required PDU activities. This will have no detrimental effect upon the test since the heartbeat is used as a backup in case a change of state PDU is lost in transmission. Increasing the heartbeat period would mean that it could take up to fifteen minutes to replace the lost PDU as opposed to eleven minutes. Also, as discussed in Section 4.3.1.2.b), only 30 PDUs were lost out of 96000 during normal network operation. None of the PDUs lost were change of state PDUs that required replacement.
- b) Prior to the beginning of entity movement, turn off the heartbeat. This will result in Janus issuing only change of state PDUs as the changes occur. This feature was built into Janus as a contingency in case the simulation experienced a problem with processor overload. As just stated, the heartbeat is needed within the SE only as a backup in case of lost PDUs. VSTARS will continue too dead reckon on the last PDU received until a new one is received. Furthermore, the rate of PDU loss is dependent upon the PDU transmission rate. Lowering the PDU rate by turning off the heartbeat will lower the loss rate to the point that any errant entity will be lost in the noise.
- c) If the previous solutions do not solve the problem, it is always possible to decrease the amount of activity within a scenario. Initial observations have established that there appears to be a threshold of activity above which the anomaly occurs and realism disappears. If required, this threshold will be quantified and the scenarios used during the ETE Test will be revised to stay below the threshold. Initial indications are that even if we were required to remain below this threshold, there would still be many more entities conducting tactical movement than can be found using live test ranges.

Once the problem is solved, an addendum will be published to this report detailing the solution arrived at and the observations of the operators at that time.

5.2 End-To-End Test Synthetic Environment

5.2.1 Perform Validation (Step 7)

The validation of the ETE Phase 2 OT SE was performed by the ETE Test V&V team, assisted by Northrop Grumman and the Joint STARS Joint Test Force, during the ETE risk reduction test.

The validation of the ETE Phase 2 OT SE was intended to ensure that the integrated simulations are adequate to satisfy the ETE Test requirements such that the SE behavior and performance map sufficiently to real-world counterparts for the specific application; performances and representations of the simulated entities are sufficient to support the intended application; and testing has been done to address acceptance criteria.

This activity consists of five basic tasks: Establish context for validation activities, evaluate configuration interoperability, perform effectiveness evaluation, evaluate test results, and evaluate operator performance.

5.2.1.1 Procedures

- a) **Establish Context for Validation Activities:** This validation task has been performed in preparation for the ETE risk reduction test. The scope of the validation effort is specified by the Phase 2 Verification and Validation Plan for the End-to-End Test. No new acceptability criteria have been identified during the course of four functionality and integration tests, and potential shortcomings and limitations of the SE have been identified.
- b) **Evaluate Configuration Interoperability:** This validation task was performed by the V&V team following the ETE risk reduction test. It consisted of verifying the mapping of the individual components of the SE to the detailed design and validating that the individual components performed as required by the design. PDU log files and observer log files were used to conduct this validation task.
- c) **Perform Effectiveness Evaluation:** This validation task is a follow-on to the previous task. Once it was ascertained that the individual components performed as required, their effectiveness was ascertained by tracing exercise performance data to the acceptability criteria and evaluating the data for accuracy, sufficiency, and appropriateness. PDU log files and observer log files were used to conduct this validation task.
- d) **Evaluate Test Results:** This validation task is also a follow-on to the previous task. After the effectiveness of the individual components were determined, the effectiveness of the overall SE was evaluated and compared to the real world represented by the SE. PDU log files and observer log files were used to conduct this validation task.
- e) **Evaluate Operator Performance:** This validation task considered operator performance while working within the SE vice the real world. Advanced Technology Work Station (ATWS) operators and LGSM operators were queried by the test observers after each test run as to differences in individual performance between the two environments. Differences and their impact upon the test were noted in the observer log.

5.2.1.2 Results

- a) **Establish Context for Validation Activities:** As stated above, this task was performed prior to the risk reduction test. During the conduct of the risk reduction test, no new acceptability criteria were identified. If required to implement the third solution to the Janus problem, identified in 5.1.1.3c), this would place a limitation upon the SE as previously discussed.
- b) **Evaluate Configuration Interoperability:** The configuration interoperability of the SE has previously been discussed within this report as a part of the verification of the SE and its components. Further evidence of the SE configuration interoperability is attached as Appendix G: Section G1: Risk Reduction Test Quick-Look Report and Appendix G: Section G2: Operational Measures Report.
- c) **Perform Effectiveness Evaluation:** The effectiveness of the SE has also been discussed as a part of the verification of the SE and its components. It is apparent that the SE is an effective tool in evaluating the End-to-End Test concept under operational conditions. The fact that actual operators are able to perform operational functions for the first time using the SE is further proof that the SE is an effective tool for operational testing. In addition, actual operational measures taken from the Joint STARS multiservice operational test and evaluation (MOT&E) were evaluated using the SE. The results of this evaluation is included as Appendix G: Section G2.
- d) **Evaluate Test Results:** The primary deviation of the SE from the real world, realistic vehicle movement, has previously been discussed and solutions have been proposed. Another comment about the SE deviation from the real world was made by an Air Force operator after performing a six-hour mission in a mock-up of the E-8C. To paraphrase him, I knew it wasn't real because it didn't stink like jet fuel and the plane didn't roll when we turned. Other than that, it was Joint STARS.

Aside from the fact that the mock-up of the E-8C does not stink like jet fuel and does not roll, reviews of log sheets, operator comments and test reports reveal that the ETE Test SE is a realistic representation of the real world.

As an aside, it is almost impossible to compare the SE as a whole to the real world because the real world has never existed. The ETE Test concept calls for a major land battle involving nearly 10,000 potential targets, at which ATACMS missiles are targeted and fired. None of the fielded and simulated systems within the ETE Test have ever been used under these conditions. The closest they have come to this environment was post Desert Storm Southwest Asia (SWA) deployments and Bosnia. Thus the real world becomes what operators and subject matter experts think will happen, or hope will happen.

- e) **Evaluate Operator Performance:** Generally, the operators performed as well in the SE as they would perform in the real world. As previously mentioned, this issue is complicated by the fact that operators throughout the SE were able to perform tasks that they had never been

able to perform in the real world. Also, as previously mentioned, the operator's level of training and the ability to train complicated this issue, since the ETE Test SE turned out to be the best trainer available.

Evaluations of operator performance during the risk reduction test are contained in Appendix F: Operator Observer Logs and Appendix G: Section G1: Operational Measures Report. In summary, within the constraints of the environment portrayed by the SE, anything the operators could do in the real world they could do in the SE.

6. Conclusion

This verification and validation report covers the final four steps of the DIS Nine Step VV&A Process as referred to in the *Recommended Practice for Distributed Interactive Simulation -- Verification, Validation, and Accreditation*, 4 November 1996 and completes the verification and validation of the ETE Test synthetic environment for the ETE Phase 2 operational Test. In addition, it completes the verification and validation of the individual simulation nodes of the ETE Test SE for the ETE Phase 2 operational test.

The results of this phase of the V&V, along with the results of the Phase 1 V&V, will be applied to the requirements and acceptability criteria for the ETE Test and a recommendation will be made as to whether the ETE Test SE should be accredited for use during the ETE Phase 2 operational test.

A review of the results, however, would indicate that the ETE Test SE is a very robust and realistic environment except for the movement problem discussed earlier. Since two possible and one absolute solution to this problem exist, it would appear that the ETE Test SE is ready to be used for the ETE Phase 2 operational test.

Acronyms and Definitions

ACE	analysis and control element
ADS	advanced distributed simulation
AFATDS	Advanced Field Artillery Tactical Data System
ATACMS	Army Tactical Missile System
ATWS	Advanced Technology Work Station
COTS	commercial off-the-shelf
DIS	distributed interactive simulation
ES	entity state
ES PDU	entity state protocol data unit
ETE	End-to-End Test
Force	a menu option that opens the Scenario Forces Editor which is used to modify system numbers, aggregation and task force assignments for a Janus scenario
HQ	headquarters
IEEE	Institute of Electrical and Electronics Engineers
JADS	Joint Advanced Distributed Simulation, Albuquerque, New Mexico
Janus	interactive, computer-based simulation of combat operations
Joint STARS	Joint Surveillance Target Attack Radar System
km	kilometer
LGSM	light ground support module
M&S	modeling and simulation
MOT&E	multiservice operational test and evaluation
MTI	moving target indicator
OT	operational test
PCNIU	personal computer network interface unit
PDU	protocol data unit
SAR	synthetic aperture radar
SATCOM	satellite communications
SE	synthetic environment
SME	subject matter experts
Spectrum™	an instrumentation suite used to measure bandwidth utilization
STRICOM	U.S. Army Simulation, Training and Instrumentation Command
SWA	Southwest Asia
TAC	target analysis cell
TACFIRE	tactical fire
TAFSM	Tactical Army Fire Support Model
TCAC	Test Control and Analysis Center
TRAC	U.S. Army Training and Doctrine Command (TRADOC) Analysis Center
TRADOC	U.S. Army Training and Doctrine Command
V&V	verification and validation
VSTARS	Virtual Surveillance Target Attack Radar System

VV&A
WSMR

verification, validation and accreditation
White Sands Missile Range

Appendix A: Janus Suite Price List

Suggested Equipment For Janus As VSTARS Stimulator

Model	Base Product A4318A	
C200	200 MHz PA-RISC 8200 CPU	\$13,000
Configured with:		
4GB FWD SCSI-2 low profile disk drive (1.6" high)	1,700	
4GB DDS-2 DAT drive		1,400
HP-UX 10.x Instant Ignition		200
Keyboard		100
128 MB ECC memory module		900
HP VISUALIZE-EG card (requires 1 GSC slot)		1,000
19"/18.3 viewable color monitor		1,300
Cable for DDS-2 drive		100
Terminator for cable		50
total estimate		19,800

Several options exist: the 256 MB ECC memory module is about \$3K, both larger and smaller monitors are offered, an additional disk drive can be added, and you should check with your local systems support for what you need for networking. We use twisted pair cables, some use thin LAN, etc. You may need extra cards. You might want the OS media as well as the preloaded we have shown here; if so, you will need a CD-ROM drive. I used the HP web site for some of the above info: see <http://www.hp.com/cgi-bin/hpwebcat/config3.pl/hp9kw>.

Different disk drives might be chosen to suit your connections. Consult with HP experts to make sure of system compatibility and connecting compatibility.

The C240 with a 236 MHz processor is out and costs about \$5K more.

Appendix B: Analysis of Janus PDUs

Sample of 071398 WSMR (Janus) PDU Analysis

Site	Host	Log Time (msec)	Game Time (msec)	Entity Number	Latitude	Longitude	Velocity X (m/sec)	Velocity Y (msec)	Velocity Z (msec)	UTM Northing	UTM Easting
23	81	65406113	18000472	2653	30.5439	46.37677	0	0	0	3379864	632062
23	81	65406113	18000472	2654	30.544	46.37549	0	0	0	3379875	631939
23	81	65406113	18000472	2655	30.5443	46.37635	0	0	0	3379904	632022
23	81	65406113	18000472	2656	30.5443	46.37858	0	0	0	3379910	632236
23	81	65406114	18000806	2658	30.5445	46.37948	0	0	0	3379933	632322
23	81	65406114	18000806	2659	30.5439	46.37911	0	0	0	3379862	632287
23	81	65406114	18000806	2660	30.5445	46.37504	0	0	0	3379930	631896
23	81	65406114	18000806	2661	30.5449	46.3749	0	0	0	3379969	631882
23	81	65406119	18001138	2663	30.5437	46.37436	0	0	0	3379842	631831
23	81	65406119	18001138	2664	30.5431	46.37487	0	0	0	3379770	631881
23	81	65413137	18007804	2766	30.4136	46.35791	1.969617	1.969617	-4.74379	336540	630427
23	81	65413137	18007804	2767	30.4142	46.35791	1.879705	2.056481	-4.74505	336546	630426
23	81	65413137	18008138	2768	30.4147	46.35791	1.879732	2.056507	-4.74503	336551	630425
23	81	65413137	18008138	2769	30.4156	46.3579	1.969318	2.146093	-4.96061	336561	630423
23	81	65413137	18008138	2770	30.416	46.35789	1.879811	2.056586	-4.74496	336566	630422
23	81	65413137	18008138	2771	30.4063	46.35781	1.969188	1.969188	-4.74414	336459	630427
23	81	65484119	18078786	3830	31.5318	46.19843	2.842348	1.251226	-4.67828	348916	613773
23	81	65484119	18078786	3831	31.5327	46.19866	2.88727	1.207753	-4.67765	348926	613794
23	81	65484119	18078786	3832	31.5332	46.19878	2.887297	1.20778	-4.67763	348931	613805
23	81	65484124	18079120	3833	31.534	46.19901	2.88735	1.207833	-4.67758	348941	613826
23	81	65484124	18079120	3834	31.5345	46.19913	2.887377	1.20786	-4.67756	348946	613836
23	81	65484124	18079120	3835	31.5353	46.19936	2.794934	1.115418	-4.4644	348955	613858
23	81	65484124	18079120	3836	31.5358	46.19948	2.887456	1.20794	-4.67749	348960	613868
23	81	65549104	18144104	4809	31.1173	46.42403	-3.83013	-2.76952	7.69744	344341	635787
23	81	65549105	18144104	4810	31.1173	46.42403	-3.83013	-2.76952	7.69744	344342	635787
23	81	65549105	18144104	4811	31.1173	46.42403	-3.83013	-2.76952	7.69744	344343	635787
23	81	65549105	18144104	4812	31.1173	46.42403	-3.83013	-2.76952	7.69744	344344	635787
23	81	65550094	18144438	4813	31.1173	46.42403	-3.83013	-2.76952	7.69744	344345	635787
23	81	65550094	18144438	4814	31.1173	46.42403	-3.83013	-2.76952	7.69744	344346	635787
23	81	65550095	18144438	4815	31.1173	46.42403	-3.83013	-2.76952	7.69744	344347	635787
23	81	65550095	18144438	4816	31.1173	46.42403	-3.83013	-2.76952	7.69744	344348	635787
23	81	65550095	18144438	4817	31.1173	46.42403	-3.83013	-2.76952	7.69744	344349	635787
23	81	65550095	18144770	4818	31.1173	46.42403	-3.83013	-2.76952	7.69744	344343	635787
23	81	65550095	18144770	4819	31.4357	47.25588	0	0	0	3480091	714400
23	81	65550095	18144770	4820	31.4493	47.25622	0	0	0	3481597	714401

Appendix C: Section C1: Janus Monitor Results

TAFSM Entity Locations - Vignette 3 (Scenario 903)

STATE PDU outside box for Unit 9905
XLL, UTM_X, XUR = 545.0 717.4 770.0
YLL, UTM_Y, YUR = 3320.0 3299.0 3545.0
STATE PDU outside box for Unit 9906
XLL, UTM_X, XUR = 545.0 710.5 770.0
YLL, UTM_Y, YUR = 3320.0 3293.5 3545.0
STATE PDU outside box for Unit 9907
XLL, UTM_X, XUR = 545.0 712.2 770.0
YLL, UTM_Y, YUR = 3320.0 3297.0 3545.0
STATE PDU outside box for Unit 9908
XLL, UTM_X, XUR = 545.0 714.5 770.0
YLL, UTM_Y, YUR = 3320.0 3296.5 3545.0
STATE PDU outside box for Unit 9909
XLL, UTM_X, XUR = 545.0 707.8 770.0
YLL, UTM_Y, YUR = 3320.0 3294.8 3545.0
STATE PDU outside box for Unit 9910
XLL, UTM_X, XUR = 545.0 708.1 770.0
YLL, UTM_Y, YUR = 3320.0 3295.0 3545.0
STATE PDU outside box for Unit 9911
XLL, UTM_X, XUR = 545.0 708.1 770.0
YLL, UTM_Y, YUR = 3320.0 3294.6 3545.0
STATE PDU outside box for Unit 9912
XLL, UTM_X, XUR = 545.0 709.6 770.0
YLL, UTM_Y, YUR = 3320.0 3296.1 3545.0
STATE PDU outside box for Unit 9913
XLL, UTM_X, XUR = 545.0 709.9 770.0
YLL, UTM_Y, YUR = 3320.0 3296.3 3545.0
STATE PDU outside box for Unit 9914
XLL, UTM_X, XUR = 545.0 709.9 770.0
YLL, UTM_Y, YUR = 3320.0 3295.9 3545.0
STATE PDU outside box for Unit 9915
XLL, UTM_X, XUR = 545.0 709.5 770.0
YLL, UTM_Y, YUR = 3320.0 3294.2 3545.0
STATE PDU outside box for Unit 9916
XLL, UTM_X, XUR = 545.0 709.8 770.0
YLL, UTM_Y, YUR = 3320.0 3294.4 3545.0
STATE PDU outside box for Unit 9917
XLL, UTM_X, XUR = 545.0 709.8 770.0
YLL, UTM_Y, YUR = 3320.0 3294.0 3545.0
STATE PDU outside box for Unit 9918
XLL, UTM_X, XUR = 545.0 711.1 770.0
YLL, UTM_Y, YUR = 3320.0 3296.7 3545.0
STATE PDU outside box for Unit 9919
XLL, UTM_X, XUR = 545.0 711.4 770.0
YLL, UTM_Y, YUR = 3320.0 3296.9 3545.0
STATE PDU outside box for Unit 9920
XLL, UTM_X, XUR = 545.0 711.4 770.0
YLL, UTM_Y, YUR = 3320.0 3296.5 3545.0
STATE PDU outside box for Unit 9921
XLL, UTM_X, XUR = 545.0 710.9 770.0
YLL, UTM_Y, YUR = 3320.0 3298.4 3545.0
STATE PDU outside box for Unit 9922

Appendix C: Section C2: Location of Fort Sill Entities as Supplied by TAFSM

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JUL 08, 98 3:29		stdin		Page 1/1	
Entity	MGRS	LATLONG	UTM	EASTING	NORTHING
FDC:FSE	38RQU190019;	29 49 41.39 N, 47 15 59.27 E;	719100	3301900	38
FDC:1/14	38RQU191026;	29 50 4.05 N, 47 16 3.51 E;	719100	3302600	38
FDC:A/1/14	38RQU192034;	29 50 29.95 N, 47 16 7.82 E;	719200	3303400	38
FU:1/1/A/1/14	38RQU191031;	29 50 20.28 N, 47 16 3.88 E;	719100	3303100	38
FU:2/1/A/1/14	38RQU189034;	29 50 30.14 N, 47 15 56.65 E;	718900	3303400	38
FU:3/1/A/1/14	38RQU19304;	29 50 6.39 N, 47 16 31.5 E;	719300	330400	38
FU:1/2/A/1/14	38RQU202035;	29 50 32.56 N, 47 16 45.13 E;	720200	3303500	38
FU:2/2/A/1/14	38RQU200038;	29 50 42.43 N, 47 16 37.91 E;	720000	3303800	38
FU:3/2/A/1/14	38RQU204038;	29 50 42.17 N, 47 16 52.80 E;	720400	3303800	38
FU:1/3/A/1/14	38RQU181021;	29 49 48.45 N, 47 15 25.91 E;	718100	3302100	38
FU:2/3/A/1/14	38RQU179024;	29 49 58.32 N, 47 15 18.68 E;	717900	3302400	38
FU:3/3/A/1/14	38RQU183024;	29 49 58.06 N, 47 15 33.58 E;	718300	3302400	38
FDC:B/1/14	38RQT180990;	29 48 7.88 N, 47 15 19.93 E;	718000	3299000	38
FU:1/1/B/1/14	38RQT168988;	29 48 2.14 N, 47 14 35.11 E;	716800	3298800	38
FU:2/1/B/1/14	38RQT166991;	29 48 12.01 N, 47 14 27.89 E;	716600	3299100	38
FU:3/1/B/1/14	38RQT170991;	29 48 11.76 N, 47 14 42.78 E;	717000	3299100	38
FU:1/2/B/1/14	38RQU178012;	29 49 19.43 N, 47 15 14.08 E;	717800	3301200	38
FU:2/2/B/1/14	38RQU176015;	29 49 29.29 N, 47 15 6.86 E;	717600	3301500	38
FU:3/2/B/1/14	38RQU180015;	29 49 29.04 N, 47 15 21.75 E;	718000	3301500	38
FU:1/3/B/1/14	38RQT168980;	29 47 36.17 N, 47 14 34.53 E;	716800	3298000	38
FU:2/3/B/1/14	38RQT166983;	29 47 46.04 N, 47 14 27.31 E;	716600	3298300	38
FU:3/3/B/1/14	38RQT170983;	29 47 45.79 N, 47 14 42.20 E;	717000	3298300	38
FDC:C/1/14	38RQU224015;	29 49 26.21 N, 47 18 5.57 E;	722400	3301500	38
FU:1/1/C/1/14	38RQU316028;	29 50 2.32 N, 47 23 49.08 E;	731600	3302800	38
FU:2/1/C/1/14	38RQU314031;	29 50 12.19 N, 47 23 41.86 E;	731400	3303100	38
FU:3/1/C/1/14	38RQU318031;	29 50 11.92 N, 47 23 56.76 E;	731800	3303100	38
FU:1/2/C/1/14	38RQU329028;	29 50 1.44 N, 47 24 37.48 E;	732900	3302800	38
FU:2/2/C/1/14	38RQU327031;	29 50 11.31 N, 47 24 30.26 E;	732700	3303100	38
FU:3/2/C/1/14	38RQU331031;	29 50 11.04 N, 47 24 45.16 E;	733100	3303100	38
FU:1/3/C/1/14	38RQU306013;	29 49 14.30 N, 47 23 10.69 E;	730600	3301300	38
FU:2/3/C/1/14	38RQU304016;	29 49 24.17 N, 47 23 3.47 E;	730400	3301600	38
FU:3/3/C/1/14	38RQU308016;	29 49 23.90 N, 47 23 18.36 E;	730800	3301600	38

vignette 1 (Correction made to
3rd Fu's coordinate
during run on 07/09/98)

Wednesday July 08, 98

stdin

Entity	MGRS	LAT-LONG	UTM	East.	North.	Zone
FDC:FSE	38RQT290754;	29 35 14.60 N, 47 21 51.40 E;	729000	3275400	38	
FDC:1/14	38RQT299756;	29 35 20.50 N, 47 22 24.98 E;	729900	3275600	38	
FDC:A/1/14	38RQT270775;	29 36 24.09 N, 47 20 38.69 E;	727000	3277500	38	
FU:1/1/A/1/14	38RQT258785;	29 36 57.34 N, 47 19 54.86 E;	725800	3278500	38	
FU:2/1/A/1/14	38RQT260788;	29 37 6.95 N, 47 20 2.51 E;	726000	3278800	38	
FU:3/1/A/1/14	38RQT262785;	29 36 57.08 N, 47 20 9.72 E;	726200	3278500	38	
FU:1/2/A/1/14	38RQT279794;	29 37 25.18 N, 47 21 13.56 E;	727900	3279400	38	
FU:2/2/A/1/14	38RQT281797;	29 37 34.79 N, 47 21 21.22 E;	728100	3279700	38	
FU:3/2/A/1/14	38RQT283794;	29 37 24.91 N, 47 21 28.42 E;	728300	3279400	38	
FU:1/3/A/1/14	38RQT277778;	29 36 33.37 N, 47 21 4.92 E;	727700	3277800	38	
FU:2/3/A/1/14	38RQT279781;	29 36 42.98 N, 47 21 12.58 E;	727900	3278100	38	
FU:3/3/A/1/14	38RQT281778;	29 36 33.11 N, 47 21 19.78 E;	728100	3277800	38	
FDC:B/1/14	38RQT315753;	29 35 9.69 N, 47 23 24.17 E;	731500	3275300	38	
FU:1/1/B/1/14	38RQT298767;	29 35 56.27 N, 47 22 22.10 E;	729800	3276700	38	
FU:2/1/B/1/14	38RQT300770;	29 36 5.88 N, 47 22 29.76 E;	730000	3277000	38	
FU:3/1/B/1/14	38RQT302767;	29 35 56.01 N, 47 22 36.96 E;	730200	3276700	38	
FU:1/2/B/1/14	38RQT321776;	29 36 23.95 N, 47 23 48.22 E;	732100	3277600	38	
FU:2/2/B/1/14	38RQT323779;	29 36 33.56 N, 47 23 55.88 E;	732300	3277900	38	
FU:3/2/B/1/14	38RQT325776;	29 36 23.68 N, 47 24 3.08 E;	732500	3277600	38	
FU:1/3/B/1/14	38RQT318758;	29 35 25.72 N, 47 23 35.70 E;	731800	3275800	38	
FU:2/3/B/1/14	38RQT320761;	29 35 35.33 N, 47 23 43.36 E;	732000	3276100	38	
FU:3/3/B/1/14	38RQT322758;	29 35 25.45 N, 47 23 50.56 E;	732200	3275800	38	
FDC:C/1/14	38RQT355750;	29 34 57.25 N, 47 25 52.50 E;	735500	3275000	38	
FU:1/1/C/1/14	38RQT341761;	29 35 33.91 N, 47 25 1.36 E;	734100	3276100	38	
FU:2/1/C/1/14	38RQT343764;	29 35 43.51 N, 47 25 9.02 E;	734300	3276400	38	
FU:3/1/C/1/14	38RQT345761;	29 35 33.64 N, 47 25 16.21 E;	734500	3276100	38	
FU:1/2/C/1/14	38RQT365773;	29 36 11.23 N, 47 26 31.43 E;	736500	3277300	38	
FU:2/2/C/1/14	38RQT367776;	29 36 20.83 N, 47 26 39.10 E;	736700	3277600	38	
FU:3/2/C/1/14	38RQT369773;	29 36 10.96 N, 47 26 46.29 E;	736900	3277300	38	
FU:1/3/C/1/14	38RQT361751;	29 35 0.09 N, 47 26 14.86 E;	736100	3275100	38	
FU:2/3/C/1/14	38RQT363754;	29 35 9.69 N, 47 26 22.52 E;	736300	3275400	38	
FU:3/3/C/1/14	38RQT365751;	29 34 59.82 N, 47 26 29.71 E;	736500	3275100	38	

Vignette 2

Wednesday July 08, 98

stdin

Entity	MGRS	LAT-LONG	UTM	East.	North.	Zone
FDC:FSE	38RQT186990;	29 48 7.49 N, 47 15 42.26 E;	718600	3299000	38	
FDC:1/14	38RQT174990;	29 48 8.26 N, 47 14 57.59 E;	717400	3299000	38	
FDC:A/1/14	38RQT105935;	29 45 14.00 N, 47 10 36.88 E;	710500	3293500	38	
FU:1/1/A/1/14	38RQT078948;	29 45 57.85 N, 47 8 57.32 E;	707800	3294800	38	
FU:2/1/A/1/14	38RQT081950;	29 46 4.16 N, 47 9 8.62 E;	708100	3295000	38	
FU:3/1/A/1/14	38RQT081946;	29 45 51.17 N, 47 9 8.34 E;	708100	3294600	38	
FU:1/2/A/1/14	38RQT096961;	29 46 38.96 N, 47 10 5.21 E;	709600	3296100	38	
FU:2/2/A/1/14	38RQT099963;	29 46 45.27 N, 47 10 16.51 E;	709900	3296300	38	
FU:3/2/A/1/14	38RQT099959;	29 46 32.28 N, 47 10 16.23 E;	709900	3295900	38	
FU:1/3/A/1/14	38RQT095942;	29 45 37.33 N, 47 10 0.16 E;	709500	3294200	38	
FU:2/3/A/1/14	38RQT098944;	29 45 43.65 N, 47 10 11.46 E;	709800	3294400	38	
FU:3/3/A/1/14	38RQT098940;	29 45 30.66 N, 47 10 11.18 E;	709800	3294000	38	
FDC:B/1/14	38RQT122970;	29 47 6.58 N, 47 11 42.61 E;	712200	3297000	38	
FU:1/1/B/1/14	38RQT111967;	29 46 57.52 N, 47 11 1.46 E;	711100	3296700	38	
FU:2/1/B/1/14	38RQT114969;	29 47 3.83 N, 47 11 12.76 E;	711400	3296900	38	
FU:3/1/B/1/14	38RQT114965;	29 46 50.84 N, 47 11 12.48 E;	711400	3296500	38	
FU:1/2/B/1/14	38RQT109984;	29 47 52.84 N, 47 10 55.21 E;	710900	3298400	38	
FU:2/2/B/1/14	38RQT112986;	29 47 59.14 N, 47 11 6.52 E;	711200	3298600	38	
FU:3/2/B/1/14	38RQT112982;	29 47 46.16 N, 47 11 6.24 E;	711200	3298200	38	
FU:1/3/B/1/14	38RQT126989;	29 48 8.02 N, 47 11 58.85 E;	712600	3298900	38	
FU:2/3/B/1/14	38RQT129991;	29 48 14.33 N, 47 12 10.16 E;	712900	3299100	38	
FU:3/3/B/1/14	38RQT129987;	29 48 1.34 N, 47 12 9.87 E;	712900	3298700	38	
FDC:C/1/14	38RQT145965;	29 46 48.92 N, 47 13 7.85 E;	714500	3296500	38	
FU:1/1/C/1/14	38RQT134972;	29 47 12.33 N, 47 12 27.41 E;	713400	3297200	38	
FU:2/1/C/1/14	38RQT137974;	29 47 18.64 N, 47 12 38.72 E;	713700	3297400	38	
FU:3/1/C/1/14	38RQT137970;	29 47 5.65 N, 47 12 38.44 E;	713700	3297000	38	
FU:1/2/C/1/14	38RQT152990;	29 48 9.64 N, 47 13 35.70 E;	715200	3299000	38	
FU:2/2/C/1/14	38RQT155992;	29 48 15.95 N, 47 13 47.01 E;	715500	3299200	38	
FU:3/2/C/1/14	38RQT155988;	29 48 2.96 N, 47 13 46.72 E;	715500	3298800	38	
FU:1/3/C/1/14	38RQT153969;	29 47 1.41 N, 47 13 37.91 E;	715300	3296900	38	
FU:2/3/C/1/14	38RQT156971;	29 47 7.71 N, 47 13 49.22 E;	715600	3297100	38	
FU:3/3/C/1/14	38RQT156967;	29 46 54.72 N, 47 13 48.93 E;	715600	3296700	38	

Vignette 3

Wednesday July 08, 98

stdin

Appendix C:
Section C3: TRAC-WSMR Log Sheets

ETE EVENT LOG

Location: WSMR
 Test Event RR
 Test Date 7 Jul 98
 Recorder Name: Capt Houser

Time
(Zulu)

Comments

1300	Log on hp/start Janus / Log on
1304	ping test 100% wsmr router 3% FtSill & uts
1306	check time - .000320 sec
1307	network checks FtSill problems, wsmr not receiving all paks OK (1323z)
1310	Vignette 1 / Scenario 94 / 9897 entities / 3/5/659/ RS=10
1315	Terrain UL 31:32:34, 45:28:39 UR 31:31:25, 47:15:41 LL 30:50:47, 45:28:12 LR 29:59:42, 47:13:34
1331	Start Janus Dis at 59:59 / 13:30:50 z
1433	Janus 2:02 / 14:32:45 z
1533	Janus 3:02 / 15:32:45 z
1545	Approximately 500 moving entities
1602	Janus 3:31 / 16:01:47 z
1631	Janus 3:59:59 / 16:30:46 z
1702	Janus 4:30:59 / 17:01:46 z
1731	Janus 5:00:59 / 17:31:46 z
1801	Janus 5:30 / 18:00:47 z
1832	Janus 6:01 / 18:31:47 z

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ETE EVENT LOG

Location: WSMR
 Test Event RR
 Test Date 7 Jul 98
 Recorder Name: Capt Houser

Time
(Zulu)

Comments

1901	Jams 06:30 / 19:00:47 z
1934	Jams 7:03 / 19:33:47 z
2005	Jams 7:34:01 / 20:04:47 z
2021	Accelerated vehicles @ 31:0:43, 46:11:5 / Jams 07:48
2032	Jams 08:00:46 / STOP Jams Dis
2032	Stop Logger 379067 plus
2035	Jams Intrafire Rs=20 Artillery firing
2048	End Jams @ 12:45
2054	Logfile analysis / 1639 separate entities moved during vignette 1
2055	Log off hp & indy
2108	Finished switching JADS equip to new UPS.

Max of 601 entities moving at one time

ETE EVENT LOG

Location: USMR
 Test Event RR
 Test Date 8 Jul 98
 Recorder Name: Capt Hauser

Time
(Zulu)

Comments

1250	Log on hp / indy
1254	Ping test 100% loss usmr router, 3% Ft. Sill, ut's
1255	Check time - .000113 sec
1256	Vignette 1/9897 entities / 315/659 / RS = 2
1258	Ready for network checks, conference net called
1303	Network check router problem at Ft. Sill (1308z) OK (1310z)
1315	Start Janus ^{DIS} 59:59 / 1315:11z / same terrain as yesterday
1348	Janus 1:33 / 13:48:11z
1440	Janus 2:25 / 14:40:11z
1500	Janus interactive planned artillery missions for 7:59:00 (30:31:5, 46:51:18)
1519	Janus 3:03:59 / 15:19:13z
1545	Janus 3:29:59 / 15:45:13z
1619	Janus 4:03:59 / 16:19:13z
1645	Janus 4:29:59 / 16:45:13z
1715	Janus 4:59:59 / 17:15:13z
1747	Janus 5:32 / 17:47:14z

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ETE EVENT LOG

Location: WSMR

Test Event RR

Test Date 8 Jul 98

Recorder Name: Capt Houser

Time
(Zulu)

Comments

[illegible]

ETE EVENT LOG

Location: WSMR
 Test Event RR
 Test Date 9 Jul 98
 Recorder Name: Capt Houser

Time
(Zulu)

Comments

1250	Reboot Hp & Log In to Indy
1255	Ping_test 100% loss wsmr.router, 3% Atsill & uts
1258	check-time -.000073 sec.
1300	Vignette 2, scenario 902 / 9757 entities / 35/650 / RS=5
1300	Ready for network checks, Conference not called
1304	Network Checks - OK 1309z
1313	Start logger 070998-test90201-wsmr.log
1316	Start Jams DS 59:59 / 1316:20z
1337	Jams stop 1:21
1338	Stop logger 1910Z plus
1339	Reboot HP
1345	Vignette 1, scenario 901 / RS=99
1356	Start logger 070998-test90101-wsmr.log
1351	Start Jams DS 59:59 / 13:51:52z
1430	Jams 1:38 / 14:29:50z
145	Jams 2:00 / 14:51:51z

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ETE EVENT LOG

Location: WSMR
 Test Event RR
 Test Date 9 Jul 98
 Recorder Name: Capt Houser

Time
(Zulu)

Comments

1502	Not receiving #7 TAFSM expdu (30/31) - OK Invalid TAFSM entity location
1507	TAFSM expdu locations as well as detonation information will be written to 070998-test90101-tafsm.rpt.txt
1537	Janus 2:44:59 / 15:36:52 Z
1552	Janus 2:59:59 / 15:52:52 Z
1637	Janus 3:45:59 / 16:37:52 Z
1656	Janus 4:03:59 / 16:55:52 Z
1722	Janus 4:29:59 / 17:21:52 Z
1803	Janus 5:11 / 18:02:52 Z
1919	Janus 6:27 / 19:18:52 Z
1952	Janus 7:00 / 19:51:53 Z
2002	Stop Janus 7:10:40
2003	Stop logger 335598 entities plus
2005	Received 8 detonate plus / 13 kills -- all from detonite #8
2010	Power off HP, Logout Indy

ETE EVENT LOG

Location: USMR
 Test Event RR
 Test Date 10 Jul 98
 Recorder Name: Capt Houser

Time
(Zulu)

Comments

1300	Boot HP & Log on Indy
1303	ping-test 100% loss usmr-radar, 3% Hill uts
1303	Check-time -.000271 sec
1304	Network checks - network problems at TCAC fixed 1310z
1306	Vignette 3, scenario 903 / 9904 ended / 315/660
1309	Terrain LL 31:48:54, 45:28:38 UR 31:47:45, 47:16:12 LL 20:16:56, 45:18:10 LR 20:15:51, 47:14:12
1318	Start Logger 071098-test90301-usmr.log
1320	Start Janus DIS 0:00 / 13:20:08z
1350	Janus 0:30 / 13:50:09z
1420	Janus 59:59 / 14:20:09z
1451	Janus 1:31 / 14:51:09z
1520	Janus 2:00 / 15:20:10z
1550	Janus 2:30 / 15:50:10z
1608	Fire location (26:27:36, 47:45:36) Received detonate #1 (TAFS/M moving entities)
1613	Fire location (31:01:25, 46:14:48) Received detonate #2
1620	Janus 2:59:59 / 16:20:10z

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ETE EVENT LOG

Location: WSMK
 Test Event RR
 Test Date 10 JUL 98
 Recorder Name: Capt Houser

Time
(Zulu)

Comments

1640	Finished ^{31 entities from 5 Corps HQS} Interactive move to 31:01:23, 46:15:35
1650	Janus 3:29:59 / 16:50:10Z
1720	Janus 3:59:59 / 17:20:9Z
1750	Janus 4:29:59 / 17:50:10Z
1755	Fire Mission ^{30:33:48, 46:36:28 30:56:48, 46:52:8 30:13:18, 46:36:54} ^{30:37:25, 46:36:13 30:33:6, 46:36:28 30:56:48, 46:52:8} ^{30:50:50, 46:12:59 30:42:56, 46:28:14 30:42:56, 46:28:14} Received 27 detonates
1820	Janus 4:59:59 / 18:20:10Z
1838	Finished Interactive 5045:10Z around SE airfield 407 ADE BDE HQ around NE big lake
1855	Janus 5:35:00 / 18:55:10Z
1915	Fire Missions (30:14:57, 46:23:43) Received detonate #10
1921	Janus 6:00 / 19:21:10Z
1930	Fire Mission (30:50:41, 46:12:4) Received detonate #11, 12, 13 (30:50:42, 46:14:18)
1940	Fire Mission 30:18:55 46:36:36 Received detonate #14, 15
1952	Janus 6:32 / 19:52:10Z
2001	Fire Mission (30:50:2, 46:14:18) Received detonate #17 (30:50:0, 46:14:24) Janus not doing proper weapon effects?
2020	Stop Janus 7:00:30
2021	Stop logger 310458 plus analysis should 4620 separate mining entities

ETE EVENT LOG

Location: Wsmk
 Test Event RR
 Test Date 10 JUL 98
 Recorder Name: Capt Houser

Time
(Zulu)

Comments

1640	Finished Interactive move to 31 entites from 5 Corps HQs 31:01:23, 46:15:35
1650	Janus 3:29:59 / 16:50:10z
1720	Janus 3:59:59 / 17:20:9z
1750	Janus 4:29:59 / 17:50:10z
1755	Fire Mission 30:33:48, 46:36:28 30:56:48, 46:52:8 30:13:18, 46:36:54 30:17:15, 46:36:13 30:33:6, 46:36:28 30:56:48, 46:52:8 30:50:50, 46:12:59 30:42:58, 46:28:14 30:42:58, 46:28:14 Received 27 detonates
1820	Janus 4:59:59 / 18:20:10z
1838	Finished Interactive 5045:10N around SE airfield 407 ADE BDE HQ around NE big lake PV163133 PV178127
1855	Janus 5:35:00 / 18:55:10z
1915	Fire Missions (30:14:57, 46:23:43) Received detonate #10
1921	Janus 6:01 / 19:21:10z
1930	Fire Mission 30:50:41, 46:12:9 30:56:48, 46:52:8 30:13:18, 46:36:54 46:14:5 Received detonate #11, 12, 13 (30:50:42) 46:14:18
1940	Fire Mission 30:18:55 46:36:36 30:56:48, 46:52:8 30:13:18, 46:36:54 30:22:22 46:36:12 Received detonate #14, 15
1952	Janus 6:32 / 19:52:10z
2001	Fire Mission (30:50:2, 46:14:18) Received detonate #17 (30:50:0) 46:14:24 Janus not doing proper weapon effects?
2020	Stop Janus 7:00:30
2021	Stop logger 310458 plus analysis should 4620 separate mining entities

ETE EVENT LOG

Location: WSMR
 Test Event RR
 Test Date 13 Jul 98
 Recorder Name: Capt Houser

Time
(Zulu)

Comments

1625	Fire Mission	30:22:20, 46:24:44	Detonate #5 4 kills 506 MRL BDE HQ
1635	Fire Mission	30:42:53, 46:27:54 30:22:18, 46:24:55	Detonates #6-11
1641	Janus	3:30:59 / 16:41:05Z	
1710	Janus	3:59:59 / 17:10:03Z	
1726	Fire Mission	30:31:25, 46:50:52	Detonates 12-16 MUS MECH DIV Interactive
1813	Janus	5:02:59 / 18:13:03Z	
1816	Fire Mission	30:27:35, 46:53:47	Detonate #17
1840	Janus	5:30:00 / 18:40:04Z	
1910	Fire Mission	30:27:27, 46:52:27	Detonate #18
1914	Janus	6:04:00 / 19:14:04Z	
1920	Fire Mission	30:31:17, 46:54:1	Detonate #19,20
1940	Janus	6:30:00 / 19:40:04Z	
2006	Stop TAFSM		
2010	Stop Janus	7:00 / 20:10:04Z	
2011	Stop Lgr	30948Z plus	
2028	Log file analysis	4591 separate entities moved	Max 3268 entities moving at one time

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Appendix D: Section D1: AFATDS Message Traffic

JUL-08-98 16:28 FROM:D+SA BATTLE LAB

ID:4054427140

PAGE 2/

07_08_98_13_16_CFF.mof

When passing it
when ready →

C,19:19:37,1/14,AMC,,,AC0012,N30.50213,E046.25779,30:30:08,N,046:15:28,E
C,19:19:44,A/1/14,AMC,,,AC0012,N30.50213,E046.25779,30:30:08,N,046:15:28,E
C,19:19:52,1/1/A/1/14,AMC,,,AC0012,N30.50213,E046.25779,30:30:08,N,046:15:28,E
C,19:20:09,1/14,WR,,,AC0012,N30.50213,E046.25779,30:30:08,N,046:15:28,E
C,19:20:17,A/1/14,WR,,,AC0012,N30.50213,E046.25779,30:30:08,N,046:15:28,E
C,19:20:24,1/1/A/1/14,WR,,,AC0012,N30.50213,E046.25779,30:30:08,N,046:15:28,E
C,19:24:12,1/14,AMC,,,AC0015,N30.85090,E046.20584,30:51:03,N,046:12:21,E
D,19:24:18,,,NA,18:43:NA,AC0012,N30.50102,E046.25725,30:30:04,N,046:15:26,E
C,19:24:19,A/1/14,AMC,,,AC0015,N30.85090,E046.20584,30:51:03,N,046:12:21,E
C,19:24:27,1/1/A/1/14,AMC,,,AC0015,N30.85090,E046.20584,30:51:03,N,046:12:21,E
C,19:36:21,1/14,FIRE,,,AC0015,N30.85090,E046.20584,30:51:03,N,046:12:21,E
C,19:36:29,A/1/14,FIRE,,,AC0015,N30.85090,E046.20584,30:51:03,N,046:12:21,E
C,19:36:36,1/1/A/1/14,FIRE,,,AC0015,N30.85090,E046.20584,30:51:03,N,046:12:21,E
D,19:41:11,,,NA,18:43:NA,AC0015,N30.85245,E046.20427,30:51:09,N,046:12:15,E

Appendix D: Section D2: Example of Non Entity State PDUs Generated by Fort Sill

PDU Type	PDU_Time (msec)	Log_Time (msec)	Difference (msec)	t
Transmitter	48175347	48175515	168	
Signal	48175347	48175558	211	
Transmitter	48175999	48177141	1142	
Signal	48175999	48177297	1298	
Transmitter	48175999	48177796	1797	
Transmitter	48177947	48178110	163	
Transmitter	58387247	58388880	1633	
Transmitter	58389647	58391280	1633	
firer:018-043-018 locn:(30.180				
47.182) mg: 164310.0				
Fire	58392247	58393883	1636	
Transmitter	58392547	58394180	1633	
Transmitter	58395747	58397381	1634	
Transmitter	58395747	58397381	1634	
Transmitter	58397447	58399081	1634	
Transmitter	58398047	58399681	1634	
Transmitter	58401247	58402881	1634	
Transmitter	58401247	58402882	1635	
Transmitter	58402947	58404582	1635	
Transmitter	58407947	58409582	1635	
Transmitter	58410247	58411883	1636	
Transmitter	58410247	58411883	1636	
Transmitter	58411947	58413583	1636	
Transmitter	58415347	58416990	1643	
Signal	58415347	58417019	1672	
Transmitter	58416999	58418578	1579	
Signal	58416999	58418734	1735	
Transmitter	58417999	58419233	1234	
Transmitter	58421047	58422684	1637	
Detonation	58722301	58723982	1681	firer:018-043-018 result: Detonation
Transmitter	58997999	58999579	1580	
Signal	58998999	59000541	1542	
Transmitter	58998822	59000571	1749	
Signal	58998822	59000573	1751	
Transmitter	59000447	59002168	1721	
Transmitter	59003847	59005568	1721	
Transmitter	59006147	59007869	1722	
Transmitter	59006147	59007869	1722	
Transmitter	59007847	59009569	1722	
Transmitter	59011247	59012969	1722	
Transmitter	59013747	59015470	1723	
Transmitter	59013747	59015470	1723	
Transmitter	59016147	59017870	1723	
Transmitter	59067947	59069677	1730	
Transmitter	59070247	59071978	1731	
Transmitter	59070247	59071978	1731	
Transmitter	59071947	59073678	1731	
Transmitter	59075347	59077084	1737	
Signal	59075347	59077109	1762	
Transmitter	59076999	59078697	1698	
Signal	59077999	59078853	854	
Transmitter	59077999	59079352	1353	
Transmitter	59080347	59082079	1732	
Transmitter	59090947	59092681	1734	
Transmitter	59094147	59095881	1734	
Transmitter	59094147	59095882	1735	
Transmitter	59095847	59097581	1734	

Appendix D: Section D3: Fort Sill Site Logs

JUL-14-98 13:21 FROM: D+SA BATTLE LAB

ID: 4054427140

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ETE Site Checklist (Fort Sill)

Date: July 9, 1998 - Thursday
 Location: Fort Sill
 Test Event: Risk Reduction Test Day 3
 Test Participants: JADS (Team) GERMANY
USMA
ET-000
FTSILL

Data File System/Name: C:\etw00\home\jads\fort 1-logs
vignette 2 | vignette 1

Test Start Time: 13:04 Test Stop Time: 13:10
 Scenario Start Time: 13:14 13:50 Scenario Stop Time: 13:37 20:02
 TAFSM 13:18 14:19 TAFSM 13:18 20:02

Step #	POC	Action	Event	Go/No Go
Network Activation (site activities in support of JADS N&E)				
1		System Reset	12:49	Go
2		Connectivity Check	13:00	Go
3		Log File Checks	12:49	Go
4		Phone Checks	13:00	Go
5		Time Synchronization	13:04	Go

Step #	POC	Action	Event	Go/No Go
Bring up system (for each component at site)				
1		See AFATDS check list page 3		Go
2		See TAFSM check list page 4		Go
3		See PIU check list page 4		Go

Start remote	13:00	v2 v1	-
Start PIU	13:10		13:50
Start logger	13:14		13:50
Start JANUS	13:16		13:51
→ Start TAFSM	13:18		14:19
→ Stop TAFSM	13:36		20:02
Stop JANUS	13:36		20:02
Stop logger	13:37 (PDU)		20:02 (19:15 PDU)
Stop PIU	13:37		20:03
Stop Remote	-		20:03

ETE Site Checklist (Fort Sill)

Date: July 10, 1998 - Friday
 Location: Fort Sill
 Test Event: Risk Reduction Test
 Test Participants: JADS - (TAC)
WSMC
C. Raman
ETUARD

Data File System/Name: C:\win14\sm\ltafsm\jads\rvtl-logs
jads-v8-071098-1.log
*.xml files
vignette 3

Test Start Time: 13:03 Test Stop Time: 13:16
 Scenario Start Time: 13:18 Scenario Stop Time: 20:21

Step #	POC	Action	Event	Go/No Go
Network Activation (site activities in support of JADS N&E)				
1		System Reset	12:47	Go
2		Connectivity Check	✓	Go
3		Log File Checks	✓	Go
4		Phone Checks	13:00	Go
5		Time Synchronization	13:03	Go

Step #	POC	Action	Event	Go/No Go
Bring up system (for each component at site)				
1		See AFATDS check list page 3	12:50	Go
2		See TAFSM check list page 4	12:55	Go
3		See PIU check list page 4	12:55	Go

Start logger 13:18 'vignette 3'
 → Start TAFSM 13:21
 Start PIU/remote 13:19

Several Fire Missions completed - many were misses (bad locations?)

→ Stop TAFSM 20:20
 Stop PIU/remote 20:21
 Stop loggers 20:21 (2664 PDUs logged)

ETE Site Checklist (Fort Sill)

Date: July 13, 1998 - Monday
 Location: Fort Sill
 Test Event: JADS - Risk Reduction Test
 Test Participants: Fr. Sill Grumman
Fr. Hood
W. Sisk
T. H. S.

Data File System/Name: C:\ptwo\home\tafsm\jads\rrtl-logs\

rigette3

Test Start Time: 13:01 Test Stop Time: 13:06
 Scenario Start Time: 13:10 Scenario Stop Time: 20:10

Step #	POC	Action	Event	Go/No-Go
Network Activation (site activities in support of JADS N&E)				
1		System Reset	12:43	Go
2		Connectivity Check	13:01	Go
3		Log File Checks	13:49	Go
4		Phone Checks	13:00	Go
5		Time Synchronization	13:01	Go

Initial problem with Ciptwo - keyboard malfunction, needed to reboot and reset, after exchanging keyboards.

Step #	POC	Action	Event	Go/No-Go
Bring up system (for each component at site)				
1		See AFATDS check list page 3	13:00	Go
2		See TAFSM check list page 4	13:18	Go
3		See PIU check list page 4	13:18	Go

Start logger 13:10

Start TAFSM 13:20

Had 2+ targets arrive out of range
 Had some targets on terrain features
 Had some targets with requests for too many ATSCMS, resulting in partial missile

→ Stop TAFSM 20:06
 Stop JANUS 20:10
 Stop logger 20:12

Called in all targets to WSR before
 or just after firing

... 20:35

Appendix E: Example Comparison File of PDUs Broadcast by Janus and Received by VSTARS

PDU Comparison (Grumman-WSMR Loggers) (Hour 4 PDUs 16001-32000)												
Log Time (msec) (WSMR)	Log Time (msec) (Grumman)	Apparent Latency (msec)	Game Time (msec) (WSMR)	Game Time (msec) (Grumman)	Entity (WSMR)	Entity (Grumman)	Mean Apparent Latency (msec)	Median Apparent Latency (msec)	Max Apparent Latency (msec)	Min Apparent Latency (msec)	PDUs Lost	Percent Loss
59548612	59548680	68	12142902	12142902	3905	3905	81.4156	80	104	68	8	0.0500%
59548612	59548684	72	12142902	12142902	3906	3906						
59548612	59548688	76	12142902	12142902	3907	3907						
59548612	59548688	76	12143234	12143234	3909	3909						
59548612	59548692	80	12143234	12143234	3910	3910						
59548612	59548696	84	12143234	12143234	3911	3911						
59548612	59548696	84	12143234	12143234	3912	3912						
59548612	59548696	84	12143568	12143568	3914	3914						
59548612	59548700	88	12143568	12143568	3915	3915						
59548612	59548704	92	12143568	12143568	3916	3916						
59548612	59548704	92	12143568	12143568	3917	3917						
59549620	59549688	68	12143902	12143902	3919	3919						
59549620	59549688	68	12143902	12143902	3920	3920						
59549620	59549692	72	12143902	12143902	3921	3921						
59549620	59549696	76	12143902	12143902	3922	3922						
59549620	59549696	76	12144234	12144234	3924	3924						
59549620	59549700	80	12144234	12144234	3925	3925						
59549620	59549704	84	12144234	12144234	3926	3926						
59549620	59549704	84	12144234	12144234	3927	3927						
59549620	59549704	84	12144568	12144568	3929	3929						
59549620	59549708	88	12144568	12144568	3930	3930						
59549620	59549712	92	12144568	12144568	3931	3931						
59549620	59549712	92	12144568	12144568	3932	3932						
59550736	59550804	68	12144900	12144900	3934	3934						
59550736	59550808	72	12144900	12144900	3935	3935						
59550736	59550808	72	12144900	12144900	3936	3936						
59550736	59550812	76	12144900	12144900	3937	3937						
59550744	59550816	72	12145234	12145234	3939	3939						
59550744	59550816	72	12145234	12145234	3940	3940						
59550744	59550820	76	12145234	12145234	3941	3941						
59550744	59550824	80	12145234	12145234	3942	3942						
59550744	59550824	80	12145568	12145568	3944	3944						
59550744	59550824	80	12145568	12145568	3945	3945						
59550744	59550828	84	12145568	12145568	3946	3946						
59550744	59550832	88	12145568	12145568	3947	3947						
59551612	59551680	68	12145900	12145900	3949	3949						
59551616	59551684	68	12145900	12145900	3950	3950						
59551616	59551688	72	12145900	12145900	3951	3951						
59551616	59551688	72	12145900	12145900	3952	3952						
59551616	59551692	76	12146234	12146234	3954	3954						
59551616	59551696	80	12146234	12146234	3955	3955						
59551616	59551696	80	12146234	12146234	3956	3956						
59551616	59551700	84	12146234	12146234	3957	3957						
59551616	59551700	84	12146568	12146568	3959	3959						
59551616	59551704	88	12146568	12146568	3960	3960						
59551616	59551704	88	12146568	12146568	3961	3961						
59551616	59551708	92	12146568	12146568	3962	3962						
59552616	59552684	68	12146900	12146900	3964	3964						
59552616	59552688	72	12146900	12146900	3965	3965						
59552616	59552688	72	12146900	12146900	3966	3966						
59552616	59552692	76	12146900	12146900	3967	3967						
59552616	59552696	80	12147234	12147234	3969	3969						
59552616	59552696	80	12147234	12147234	3970	3970						
59552616	59552696	80	12147234	12147234	3971	3971						
59552616	59552700	84	12147234	12147234	3972	3972						
59552616	59552704	88	12147566	12147566	3974	3974						
59552616	59552704	88	12147566	12147566	3975	3975						
59552616	59552708	92	12147566	12147566	3976	3976						
59552616	59552712	96	12147566	12147566	3977	3977						
59553612	59553680	68	12147900	12147900	3979	3979						
59553612	59553684	72	12147900	12147900	3980	3980						
59553612	59553688	76	12147900	12147900	3981	3981						

Appendix F: Operators Observers Logs

ETE Melbourne July 7-13, 1998

This is sort of a summary. I still have my raw notes for more detail.

General comments;

The TSS's are by MOS, MI people, but they really do not do MI on this Joint STARS job. That is, they maintain a list of Radar Service Requests and they keep the SMO straight, but they really do not routinely take that one step further and even attempt to do real intel. That was sort of good news for us because they really enjoyed attempting to do that job for us in its entirety. They could coordinate more with the GSM troops and do more of an intel job routinely, but they hesitate to talk to GSM. I suppose that their job is much more challenging with multiple GSMs, but on this one GSM scenario(as opposed to multiple GSMs), they do not have much to do.

Again, GSM and TSS share duties somewhat, but the GSM troops do most of the real intel. However, the TSSes are pretty good, perhaps because they mostly operate without GSMs in training. They mostly personally know each other (the GSM troops) from some intel school that they went to together. There are two types of messages which they use to communicate- free text and UHF voice. They hesitate to employ UHF in real life. Therefore they hesitate to use it here for us(the bat phone).

Monday 13 July(last day)

Game started at 1015L

All times on this sheet local. Game went on to almost 1615L

1020 2A31 some sort of movement NE to SW. Seems to split at SW corner and follow two columns like they might be reading for attack or dispersing to avoid getting killed.

R&M 1020 Monday 13 Jul. Tobey says that SARs are not full size and not getting a label with them. Fixed later, I guess.

R&M 1030 Monday: GSM had to go down but brought it back up in about ten minutes.

R&M 1030 Monday: time line does not function??

1036 Noted vehicles parked bottom half of the area

1036 On right side of area 31, another unit moving North to south off road. Convoy moves SW then scoots over to road.

1110 That weird barrier blocking road with one mover apparently stopped by it. Barrier is huge, like a building

1115 no change in anything lately

R&M 1120 Monday 13 Jul. SARs down for about 5 to 10 minutes.

General: hour two, no big change in area 31 activity but area used a lot less

General: Area 34, general movement NW to SE along road (10 vehicles move through a specific area in A34 from 1108 to 1115)

General 1130-1145 convoy moving south to North on same route

General: Some helicopters flew north out of an area north of 2A32

1305 Noticed big star at UTM 38RPV5613485825(not in assigned area)

General hour 3: same type of activity along highway

Hour 4 1315-1415 Local. All attention given to 2A35 Generally everybody moving from center outbound. Jonathan is requesting and getting SARs (remember that he is a simulated GSM today) he thinks that he found a HQ at 38RNV88417845W0

Found armor battalion moving at bottom of GRCA.

1405 Found division or Brigade at 38RPU8165571952(not in 2A35, but noticed it anyway). No activity in 204 and 215(subsets of A33)

1430 Big buildup at 38RNU9707271506

1515 Big Battle. Major NW movements rest of GRCA but small movements elsewhere. Main supply of Hamerabi moving NE to SW

1527 Units crossed bridge at about 1525. Also some crossing where there are no bridges. SAR definitely does not find a bridge. A35 big time movement to north 1545 local stopping hear and there(maybe due to lost PDUs.

Friday 10 JUL

General background. big war day. Vignette number 3. Activity stars at 1019L. But we say 1015.

Dilbert is the SMO. He is not a real SMO but instead part of the JTF.

Big picture stuff

NA 14 has huge non realistic movement at about 1650Z(1250 L)

General movement to south all day is evidence of a build up

14 had convoys leave during 1st hour

no activity in 11-12 last hour(1300-1400L, I think)

no activity 11,12 last hour

no activity 13 3rd hour

looks like big activity at Jabila(However, not marked as active airbase)

starts at about 1800Z Go into city at about 1854 out of city at about 1858Z

(comment; Jonathan and Tobey had to go to a meeting about 1210. Only Chris was left for rest of the days)

Blow by Blow

1045L bunch of activity starts out from a little spot

NAI 2A-31 convoy moves NE to SW stopping in the area

1100L SMO seems intentionally slow (comment the TSS's)

1105L some activity in bottom edge of GRCA

1115L some river crossing activity, but seems too early

1116L big maneuvers south of GRCA

1423L 2A31 4(?) convoys entered from NE. Passed through. did not stop

SARed the area and found 3 different targets.

One defense perimeter of about 10 vehicles about 500 meters across.
Area 34; SARed the whole area. Some very strange thing. straight line (East West) blocking major route of travel Maybe this is some kind of compound.

1230L Some comm problem about did you shoot SARs 34 and 35 yet My TSSs confess to a lack of understanding about the numbering system. Found another highway west of the original highway with lots of activity.

2A 32 no activity across Euphrates river bridge.

2A-31 possible SAM site. Never did find definite air defense site

Troops had to leave for meeting. That means Tobey and Jonathan went to Joint STARS meeting. Chris was here to do the whole job.

1410L found 4 assembly areas south side of GRCA

1430L still movement on bottom

R&M 1430L SAR stuck on screen

1431L claims can observe actual attack

1500L Chris asks if these are real SARs of real Iraq taken from real plane.

1455L finds alert aircraft on alert pad(Not a pad really, but a bunch of high speed taxiways)

1500L general: seems like everything up North is dull. However, major battle at Southern border.

1500+ 2A31, small convoy came around southern half of it

1530L confirms with GSM that nothing happening first half hour except skirmishes at S border

approx. 1540 broken scope

1545 scope back

1550 crossed the bridge as radar came back up

General: everything is going north

1615 end of game(Gary calls "radar hard broke")

Debrief

AFATDS data base corrupted

First two days mish mash (blow by blow) (NO map underlays all day first day)

All times local

1131 found about a dozen targets

1133

1134 Waiting for TSS to reset SCDL

1139 All four targets in area 12 just stopped

1145 GSM reports that all messages are getting rejected(SAR requests and free text)

Big picture(general): Between 1100 and 1200 a HQ element or a couple of log convoys went out of NAI 12 in two directions.

1213 Talil airfield; Helo activity originated here but no evidence of an actual airfield (remember, no map underlays first day)

1250 Bunch of MTIs left NAI 14

General: looks like the FLOT is about the 32nd parallel

???? GSM went "down"

1257 GSM finally came up. RSR 50 (the number of a radar service request) approved. Will transmit about 50 old SARs to the GSM.

1302 voice comm. established with GSM

Simisms("simism" is something on the simulation, due to the "D" or the "S," I guess, that is different than real life.)

General agreement that SARs are much too bright and star-like. Reported directly from Jonathan to Lt. Col. McCall.

1036 Monday 13 Jul. On right side of area 31, another unit moving North to south off road. Convoy moves SW then scoots over to Road. This and others might be because of lost PDUs

1036 Monday 13 Jul Complaint that rivers shown to be much too wide. However, maybe because of the lost PDU problem, being shown as crossed without a bridge. If they are that deep ought to at least slow down at the ridge or in the soft bottom(if they are dry)

Fence around ammo dump appear much too thick and high(with big shadow)

Generally way too much clutter in SARs. Too many little cultural dots, I think.

Jonathan says that the terrain looks like tree tops. It is supposed to be low rocky area. Would be a better comparison if we made SAR images of terrain that he is used to.

Asked Jonathan if he would like to use this machine to train people. Jonathan said that it is good for MTI but not good for SAR training.

Seems to be too much time between time SAR is supposed to be shot and the time that it is shown on screen. Tobey remarked about this first day, but he seems to have recanted. The time was about 10-30 seconds vice about 10 seconds, but might have been his polling scheme.

Too much gap shows between adjacent SRS (noted 1115 Monday 13 Jul)

RADAR sights ought to look peculiar because of bright reflector. However, no sign of this. That is a SAM sight should occasionally show its radar antenna perpendicular to line between Joint STARS and target. We do not see this.

R&M means some sort of breakdown or problem that gets fixed(not intrinsic to V-STARS)

R&M About noon Friday, Tobey lost history function. Claims that does not happen in real aircraft. Somehow, mysteriously fixed later.

R&M 1430L Friday SAR stuck on screen

R&M approx. Friday 1540 broken scope
1545 scope back

R&M About 1300 first day, system is deleting RSRs. We do not know why.

R&M 1300L Friday dropped two SARs. Comment that is much better than previous days. Did not keep good track of this on previous days.

R&M Monday 13 Jul. Toby complained about all computer functions being very slow. Maybe 8 seconds for computer to react to anything. Mysterious fix later on.

R&M 1020 Monday 13 Jul. Tobey says that SARS not full size and not getting a label with them. Fixed later I guess

R&M 1030 Monday GSM had to go down but brought it back up in about ten minutes.

R&M 1030 Monday GSM had to go down but brought it back up in about ten minutes.

R&M 1030 Monday time line does not function??

R&M 1120 Monday 13 Jul. SARs down for about 5 to 10 minutes.

R&M 1030L on Monday 13Jul FTI is broken

None of the ellipse stuff(?) works)(noted Monday 13 Jul
Delays in displays all gone (back to normal) Monday 13 Jul , noon-ish

**Appendix G:
Section G1:**

**ETE Test
Functionality and Integration #4
Analysis Summary**

During the ETE Functionality and Integration (F&I) Test #4, analysis was performed to address JADS measures dealing with the network, nodes, protocol data units (PDUs), and test control. The measures addressed and the results obtained are provided below.

Network

Measure 2-1-2-2: Number of trials canceled or otherwise not used due to network problems.

Measure 2-1-3-3: Number of trials in which network connection was lost long enough to require trial cancellation

Measure 2-1-3-6: Amount of down time due to network failures.

Intent: These measures was used to identify the impacts of network problems on the F/I.

Description: During the F&I, entity state PDUs (ESPDUs) were broadcast from White Sands Missile Range (WSMR) to Melbourne via the test Control and Analysis Center (TCAC), and entity state, fire, detonate, transmit, and signal PDUs were broadcast from Fort Sill to WSMR via the TCAC.

Results:

Date	Hours Scheduled for Testing	Hours Network Unavailable for Testing	% of Time Network Unavailable	Reason Unavailable
25 Jun 98	5 hrs, 23 mins	37 mins	11.46 %	37 mins - Power spikes at WSMR caused IDNX restart
26 Jun 98	7 hrs, 32 mins	36 mins	7.96 %	35 mins - Ethernet interface/ router could not see the network at Fort Hood/Grumman 1 min - channel service unit/data service unit (CSU/DSU) at Fort Hood/Grumman went down

Total	12 hrs, 55 mins	1 hr, 13 mins	9.42 %	
--------------	------------------------	----------------------	---------------	--

The failure caused by the power spike was a result of an excessive number of components being plugged in to the uninterruptible power supply (UPS) at WSMR. This problem has been resolved by removing components from the UPS. The failures occurring on 26 Jun resolved themselves. Network and Engineering is investigating the causes of these failures.

Measure 2-1-2-3: Average and peak bandwidth used by link.

Intent: This measure was used to provide an indication of bandwidth use during F&I 4.

Description: During the operational test (OT), Spectrum™ was used to measure bandwidth utilization on the classified links connecting TCAC to Grumman and Grumman to Fort Hood. The Spectrum™ network analysis tool provides the capability to study multiple aspects of network link performance, including packet rate, load (%bandwidth utilized), packet error rate, and packet discard rate. During testing, Spectrum™ logs these data at a frequency specified by the user. For F&I 4, this specified frequency was once every 5 minutes during both days of testing.

The following performance parameter definitions are used in the reporting and discussion of the bandwidth data :

- Packet Rate - Ratio of change in total packet traffic (in and out) to change in time
 - Load - Ratio of change in total packet traffic to change in time expressed as a percentage of internal bandwidth
- Error Rate - Ratio of bad packets to total packets for elapsed time interval
- Discard Rate - Ratio of discarded packets to total packets for elapsed time interval

The following pieces of equipment were monitored to determine the bandwidth data:

- JADS router (Serial_IF_Port5) T-1 Line from TCAC to Grumman
- GRUMMAN router (Serial_IF_Port3) T1 Line from TCAC
- GRUMMAN router (Serial_IF_Port4) T-1 Line to Fort Hood

Results: The following tables show average and maximum values, respectively, for each of the Spectrum™ performance parameters for the classified network links monitored during active ETE F&I testing and for each of the performance parameters for the classified network links monitored during and immediately following active F&I testing.

NETWORK AVERAGE PERFORMANCE CHARACTERISTICS*

DATE/ TIME	NODE A	NODE B	PACKET RATE	LOAD	ERROR RATE	DISCARD RATE
25 Jun 98 1440:1857	TCAC	GRM	16.306/sec	.94%	.016%	0%
25 Jun 98 1440:1857	GRM	FT HOOD	21.47/sec	.25%	.067%	0%
26 Jun 98 1334:2037	TCAC	GRM	18.03/sec	1.01%	0%	0%
26 Jun 98 1334:2037	GRM	FT HOOD	20.81/sec	.28%	.117%	0%

* Table refers only to active test time during which PDU loggers were recording data.

NETWORK MAXIMUM PERFORMANCE CHARACTERISTICS*

DATE/ TIME	NODE A	NODE B	PACKET RATE	LOAD	ERROR RATE	DISCARD RATE
25 Jun 98 1440:1857	TCAC	GRM	27/sec	2%	1%	0%
25 Jun 98 1440:1857	GRM	FT HOOD	62/sec	4%	1%	0%
26 Jun 98 1334:2037	TCAC	GRM	22/sec	2%	0%	0%
26 Jun 98 1334:2037	GRM	FT HOOD	64/sec	4%	8%	0%

* Table refers only to active test time during which PDU loggers were recording data.

NETWORK AVERAGE PERFORMANCE CHARACTERISTICS**

DATE/ TIME	NODE A	NODE B	PACKET RATE	LOAD	ERROR RATE	DISCARD RATE
25 Jun 98 1330:2200	TCAC	GRM	13.24/sec	1.22%	.028%	0%
25 Jun 98 1300:2200	GRM	FT HOOD	13.78/sec	.128%	1.18%	0%
26 Jun 98 1330:2200	TCAC	GRM	15.9/sec	1.23%	0%	0%
26 Jun 98 1330:2200	GRM	FT HOOD	18.48/sec	.231%	.183%	0%

** Table refers to all time during which SPECTRUM was logging data, during and immediately following the test.

NETWORK MAXIMUM PERFORMANCE CHARACTERISTICS**

DATE/ TIME	NODE A	NODE B	PACKET RATE	LOAD	ERROR RATE	DISCARD RATE
25 Jun 98 1330:2200	TCAC	GRM	180/sec	68%	2%	0%
25 Jun 98 1300:2200	GRM	FT HOOD	62/sec	4%	63%	0%
26 Jun 98 1330:2200	TCAC	GRM	32/sec	42%	0%	0%
26 Jun 98 1330:2200	GRM	FT HOOD	64/sec	4%	9%	0%

** Table refers to all time during which SPECTRUM was logging data, during and immediately following the test.

Based on the data used in the compilation of the above tables, the following conclusions were reached on the load/packet, error, and discard rates for F&I 4:

Load/Packet Rate. Packet rate experienced for both classified link portions averaged around 20 packets/second. Network load (bandwidth utilized) during active test execution averaged around 1%, and peak load never exceeded 5% of link capacity during the two-day testing period. However, packet rate and network load did increase significantly over the TCAC – Grumman link immediately following active testing each day. This increase can be explained by the use of the network links immediately following active testing to import PDU logger data files to the TCAC from the distributed Grumman site. Peak loads for this link during the time immediately following test execution ranged from 42% to 68% of network capacity over the two days. Recorded packet rate decreases on the second day of testing correspond to known network outages and VSTARS problems.

Error Rate. Error packets were experienced infrequently during the two days of testing. The packet error rate average hovered around 1% for both classified link portions during active testing. There were several occasions during which a large number of error packets were recorded within the span of a few logging intervals. A 63% maximum error rate for one interval was the largest recorded, occurring over the Grumman - Fort Hood link after active testing was completed.

Discard Rate. The average packet discard rate experienced during each day of testing was zero. No packets were discarded during any day of testing.

Nodes

Measure 1-2-3-1: Degree to which advanced distributed simulation (ADS) can add assets to test execution.

Intent: This measure was intended to document how many assets ADS could add to test execution during the F&I.

Description: For the F&I, Janus scenarios were used to simulate entities and movements for a corps area of operations.

Results:

Date	Scenario	Entities
25 Jun 98	Vignette 1 (901)	9766
26 Jun 98	Vignette 2 (902)	9766

See unclassified attachment for entity by type.

Measure 2-1-3-1: Number of trials delayed, rescheduled, and/or redone due to ADS components exclusive of network unavailability.

Measure 2-1-3-5: Number of ADS system failures (severe enough to require trial cancellation).

Intent: These measures addressed the availability of ADS systems, including network interface units (NIUs) during F&I testing.

Description: For the F&I, the ADS system consisted of Janus at WSMR, Virtual Surveillance Target Attack Radar System (VSTARS), Tactical Army Fire Support Model (TAFSM) at Fort Sill, and the common ground station (CGS) at Fort Hood.

Results:

Date	Location	Hours Scheduled for Testing	Hours Unavailable for Testing	% of Time Node Unavailable	Reason Unavailable
25 Jun 98	WSMR	5 hrs, 23 mins	37 mins	11.46 %	Power spikes at WSMR caused IDNX restart
	Hood	5 hrs, 23 mins	0	0 %	
	Sill	6 hrs	0	0 %	
	Grumman	5 hrs, 23 mins	0	0 %	
26 Jun 98	WSMR	7 hrs, 32 mins	0	0 %	
	Hood	7 hrs, 32 mins	36 mins	7.96 %	Ethernet interface/ router could not see the network and the CSU/DSU went down.
	Sill	7 hrs, 25 mins	0	0 %	
	Grumman	7 hrs, 32 mins	36 mins	7.96 %	Ethernet interface/ router could not see the network and the CSU/DSU went down.
Totals	WSMR	12 hrs, 55 mins	37 mins	4.77 %	
	Hood	12 hrs, 55 mins	36 mins	4.65 %	
	Sill	12 hrs, 55 mins	0	0 %	
	Grumman	12 hrs, 55 mins	36 mins	4.65 %	

Testing for less than 1 hour of 25 Jun was scrubbed because of a power spike which incapacitated ETE testing ability at WSMR. Both Fort Hood and Grumman experienced problems on 26 Jun, with either a router or the Ethernet interface causing the problem. Fort Sill did not experience any problems on either day.

PDU Analysis

Measure 2-1-2-5: Percentage of PDUs received out of order by a network node.

Measure 2-1-2-6: Percentage of total PDUs required at a node that were delivered to that node.

Measure 2-1-2-7: Average and peak data latency between ADS nodes.

Intent: Measure out of order, lost PDUs, duplicate PDUs, PDU latency, variability, and rates.

Description: During the F&I, entity state (ESPDUs) PDUs were broadcast from WSMR to Melbourne via the TCAC, and entity state, fire, detonate, transmit, and signal PDUs will be broadcast from Fort Sill to WSMR via the TCAC.

Results:

Date	Node A	Node B	PDUs sent	PDUs rec'd	PDU rate per second	PDUs lost total / %	Duplicate PDUs	PDUs out of order	Min/ max/ mean latency
6/25	W	T	188,805	164,671	12.36	24,134 12.78%	0	0	.018/.118/.030
	T	G	164,671	164,657	10.72	14 .009%	0	0	.030/.045/.033
	S	W	233	187	.015	46 19.74%	0	0	-.35/-.03/-.03 (see Note 1)
6/26	W	T	308,916	308,898	12.35	18 .006%	0	0	.017/.139/.038
	T	G	308,898	293,258	11.72	15,640 5.06%	0	0	.028/.060/.035
	S	W	437	437	.017	0 0%	0	0	-.39/-.03/-.03 (see Note 1)
Total	W	T	497,721	473,569	12.36	24,152 4.85%	0	0	.017/.139/.034
	T	G	473,569	457,915	11.22	15,654 3.31%	0	0	.028/.060/.034
	S	W	670	624	.016	46 6.87%	0	0	-.39/-.03/-.03 (see Note 1)

G - Grumman S - Fort Sill T - TCAC W - WSMR

Note 1 - Logger clocks were not synchronized, resulting in negative latencies.

Analysis of Network Impact on PDUs

Date	Node A	Node B	PDUs sent	Network-related PDU losses	Unexplained PDU losses
			----- -- PDUs lost	----- % of PDUs sent / % of PDUs lost	----- % of PDUs sent / % of PDUs lost
6/25	W	T	188,805	24,134	0
			----- 24,134	----- 100% / 100%	----- 0% / 0%
	T	G	164,671	0	14
			----- 14	----- 0% / 0%	----- .009% / 100%
	S	W	233	0	46
			----- 46	----- 0% / 0%	----- 19.74% / 100%
6/26	W	T	308,916	0	18
			----- 18	----- 0% / 0%	----- .006% / 100%
	T	G	308,898	15,611	29
			----- 15,640	----- 5.05% / 99.81%	----- .009% / .19%
	S	W	437	N/A	N/A
			----- 0		
Total	W	T	497,721	24,134	18
			----- 24,152	----- 4.85% / 99.93%	----- .004 % / .07%
	T	G	473,569	15,611	43
			----- 15,654	----- 3.30% / 99.73%	----- .009% / .27%
	S	W	670	0	46
			----- 46	----- 0% / 0%	----- 6.87% / 100%

PDU losses on both test days were significant. Most of the losses were due to router and trunk outages resulting in a loss of connectivity of the end-to-end loop.

Measure 2-2-1-1: Degree to which ADS nodes provide for collection, data entry, and quality checking of pre- and post-trial briefing data.

Measure 2-2-1-4: Ease with which data can be retrieved, post trial, from a given node.

Intent: This measure was used to provide a mechanism for capturing unforeseen problems with data collection, data entry, and quality checking.

Description: During the F&I, automated data were collected using PDU loggers at the nodes and operational data were collected using log sheets at each node.

Results:

The data collected from the F&I test were retrieved in a fairly simple fashion. All data were sent via file transfer protocol (FTP) from the test locations involved to JADS. These data were then compressed and converted for analysis on JADS' UNIX-based analysis tools. While the data retrieval was simple, it was not entirely effective. Data from the Grumman site were not completely converted by the conversion software, with this incomplete conversion transparent to the analysts upon initial review. However, based on a similar experience from the previous ETE Test, the problem was discovered after the data analysis was initiated. The conversion process was then repeated for the Grumman data, with the second conversion completed successfully. This should not be a problem during future test events, as past experience will alert the analysts to such data conversion problems.

Test Control

Measure 2-2-2-1 Degree to which test managers can control the configurations of ADS participants, the ADS environment data, and ADS networks

Intent: This measure is intended to determine if the test manager can adequately control the test configuration of ADS participants, the ADS environment data, and ADS network both during and between test events.

Description: During the test readiness review, the baseline configuration was verified. During the test, the test controller documented all procedures used to control the test configuration, environment data, and ADS network, along with what procedures were useful, and which ones needed modification.

Measure 2-2-2-1 Degree to which test managers can control the configurations of ADS participants, the ADS environment data, and ADS networks

Intent: This measure is intended to determine if the test manager can adequately control the test configuration of ADS participants, the ADS environment data, and ADS network both during and between test events.

Results:

Procedures used to execute the test included Test Controller Checklist and Network Coordinator Checklist. Network procedures provided positive control of the network and data collection by

personnel using computer loggers at remote sites. Test control procedures allowed monitoring of critical equipment and provided necessary communication capabilities.

Appendix G:
Section G2: Operational Measures Report

For the seven below listed tasks and MOPS, a JADS observer sat next to the OWS operator at Northrop Grumman and the GSM operator at Fort Hood and asked them to perform the tasks. The operator was instructed to look anywhere in the GRCA and report when he saw any below listed activities. Performing these tasks were secondary to the operator's normal function of conducting surveillance and providing intelligence to the TAC. The operator was not informed that a certain type of activity was occurring at a certain location at a certain time. Instead, he was merely told to locate certain type of activities and provide information about it. The tasks, operator information, and the analysis performed are listed below.

Task 1: Identify an Airfield

Operator Information: Vignette 1

Game Time	Location	Activity
6:46	PV04552455	Random nonfrequent movement observed over several hours
6:49	PU53838057	Random nonfrequent movement observed over several hours

Analysis: The operators were able to identify airfields based on their electronic map (EMAP) and not the moving target indicator (MTI) feed received from VSTARS. Their observations on the activity around the airfield were based on the MTI feed, and they were able to use synthetic aperture radar (SAR) to confirm the existence of an airfield and enemy activity. The presence of an airfield and enemy activity was confirmed by looking at the movement tables for enemy activity. During the OT, this task will be changed from identify airfields to identify activity on/around airfields.

Task 2: Identify Artillery

Operator Information: Operators were not able to identify artillery units during either Vignette 1 or Vignette 3. According to the operators, artillery units do not look any different from other units when moving in a convoy down an msin supply route (MSR). When cued by other sources, they have an improved probability of confirming artillery locations as the batteries move into a firing positions. It is very difficult to identify artillery units unless the operator continually observes one or several units throughout the entire scenario.

Analysis: During the OT, JADS analysts will cue the operators to observe certain units during certain time frames. The operators will not be informed that they are looking for artillery units.

JADS analysts will try to determine if the operators can identify artillery units based on size, speed, and movement. Information provided by the operator will be documented.

Task 3: Identify Assembly Areas

Operator Information: Vignette 1

Game Time	Location	Activity
6:53	PV16651329	Approximately 25 units located in the area.

Analysis: Operator observation was verified using movement tables. According to the movement tables, a brigade headquarters with 8 combat battalions was located at/around PV16651329. This included a total of 22 companies.

Operator Information: Vignette 3

Game Time	Location	Activity
5:55	PU29239828	Approximately 25 units
5:57	PU42679633	Approximately 26 units

Analysis: Movement tables confirmed that at 5:55, an armor regiment, 2 motorized rifle regiments, and various support units were located at PU29239828. Movement tables also confirmed that at 5:57, a brigade headquarters and a maneuver battalion were located at PU42679633.

Task 4: Identify Convoys

Operator Information: Vignette 1

Game Time	Location	Activity
6:44	PV72492721	10 wheeled vehicles moving east at 38 kph

Analysis: Movement tables indicated that the nearest convoy at 6:44 at/around PV72492721 was at PV705283 and contained 22 wheeled vehicles. The operator information was inaccurate for convoy size and location. A review of the entire vignette revealed that no convoys moved at/around PV72492721 for the duration of the entire vignette. The nearest convoy was approximately 2 kilometers (km) away.

Operator Information: Vignette 3

Game Time	Location	Activity
5:58	PU45399304	Approximately 19 wheeled vehicles moving SE at 25kph
6:01	PU59599133	Approximately 16 wheeled vehicles moving SW at 20kph

Analysis: Movement tables revealed that neither of the convoy locations were correct. The nearest convoy from the first observation was approximately 3 kms away from the actual location. The nearest convoy from the second observation was approximately 8 kms away from the actual location.

Task 5: Identify Stationary Targets**Operator Information: Vignette 3**

Game Time	Location	Activity
6:15	PU45399304	Approximately 19 wheeled vehicles moving SE at 25kph
6:19	PU59599133	Approximately 16 wheeled vehicles moving SW at 20kph

Analysis: Movement tables revealed that neither of the convoy locations were correct. The nearest convoy from the first observation was approximately 3 kms away from the actual location. The nearest convoy from the second observation was approximately 8 kms away from the actual location.

Task 6: Identify Logistics Sites**Operator Information: Vignette 1**

Game Time	Location	Activity
6:37	PV1028	Approximately 7 convoys moving out of logistics site
6:37	PV5582	Major log site; approximately 10 convoys moving in/out of log site

Analysis: Movement tables confirmed that at 6:37 game time, PV1028 and PU5582 were operating as log sites. PV1028 contained the corps logistics headquarters with four company size elements. PU5528 was a major assembly area and logistics site containing 25 units to include the division headquarters, air defense artillery (ADA) units, artillery units, and logistics units.

Operator Information: Vignette 3

Game Time	Location	Activity
5:56	PV073160	Convoys moving in and out of log site
5:56	PU427787	Convoys moving in and out of log site

Analysis: Movement tables revealed that PV073160 was a log site containing a truck company with 225 vehicles. However, PU427787 was not a log site. The closest log site was approximately 7 kms away. A separate ADA battalion (Bn) was located approximately 2 kms away.

Task 7: Identify Main Supply Routes (MSR)

Operator Information: Vignette 1

Game Time	Location	Activity
6:35	PV1369—PV2524	6 convoys moving N to S over 1 hour
6:36	PV6353—PV2637	5 convoys moving NW to SE over 1 hour

Analysis: Movement tables confirmed that there were numerous convoys traveling north to south on an MSR from PV1369 to PV2524 . However, there was no MSR or convoys moving from PV6353 to PV2637. The nearest MSR at this point was at PV4547 to PV7627..

Operator Information: Vignette 3

Game Time	Location	Activity
6:03	PU1088—PU2019	Convoy route
6:10	PU2998—PU4095	Convoy route

Analysis: Movement tables revealed that neither of these sites were MSRs. Though there was scattered movement from PU1088 to PU2019, the movement was sporadic and limited. There was not enough movement to label it an MSR. PU2998 to PU4095 were 5 kms away from the nearest MSR.

Measure of Performance (MOP) 9: Maintain link between CGS and VSTARS

During the test readiness exercises, there were numerous failures in our ability to conduct link ups between VSTARS (Grumman) and the ground station module (GSM) (Fort Hood). Our initial approach was to set up monitoring tools to determine if the problem was with VSTARS, the GSM, or the network connection. Due to time constraints and cost considerations, the ETE Test team has decided to look at this link as one entity instead of three separate components during the Phase 2 OT. As a result, we will report on this as part of the network analysis for JADS measure 2-1-3-6.

MOP 11: Capacity to maintain tracks

During the risk reduction, GSM operators were able to successfully maintain tracks on all convoys that they attempted to maintain tracks on. During Vignette 1, operators initiated and maintained 29 tracks during the six-hour scenario without any problems. A questionnaire was also used to assess operators' perception of their ability to maintain tracks. The results are as follows:

Question: Rate the adequacy of VSTARS in tracking moving ground targets.

Respond: Total respondents-6. Extremely effective 3/6 Very effective 3/6

MOP 12: Ability to provide multimode radar

A questionnaire was used to determine if the GSM operators had any problems with receiving different types of radar (MTI, SAR, fixed target indicator [FTI]). A log was also maintained on the types and quantity of radar reports requested and received. Results are as follows:

Vignette	SAR Requested	SAR Received	FTI Requested	FTI Received
1	86	232	2	2
3	81	535	1	1

JADS analysts did not observe any problems in the operators' ability to request or receive the different types of radar reports. Results of questionnaire are as follows:

Question: Rate the effectiveness of VSTARS to interleave (execute both operations at the same time) MTI and SAR modes of operation.

Response: Total respondents-5. Extremely effective 1/5 Very effective 4/5

MOP 15: Operations and control (O&C) capabilities for VSTARS

The intent of this MOP was to ensure that the operators could use the workstation with VSTARS as they would with Joint Surveillance Target Attack Radar System (STARS) and confirm that VSTARS did not cause any unforeseen technical disruptions or anomalies. A questionnaire was used to determine if the GSM and operator workstation (OWS) operators had any difficulties in using their workstations with VSTARS. The results of the questionnaires are as follows:

Question: Rate the adequacy of VSTARS in responding to your immediate requests for information

Response: Total -6. Extremely effective 1/6 Very effective 5/6

Question: Rate the effectiveness of the surveillance control data link (SCDL) (T-1 line) in transferring free text message between the VSTARS and GSM

Response: Total -5. Extremely effective 2/5 Very effective 3/5

Question: Rate the effectiveness of the SCDL in transferring radar service request (RSR) messages between the GSM and VSTARS

Response: Total-5. Extremely effective 1/5 Very effective 2/5 Somewhat effective 1/5
Borderline 1/5

Question: Rate the adequacy of VSTARS in tracking moving ground targets

Response: Total-6. Extremely effective 3/6 Very effective 3/6

Question: Rate the adequacy of E-8 O&C/GSM console in displaying MTI radar data

Response: Total-5. Extremely effective 1/5 Very effective 2/5 Somewhat effective 2/5

Question: Rate the adequacy of E-8 O&C/GSM console to process and display SAR radar

Response: Total-5. Extremely effective 1/5 Very effective 3/5 Borderline 1/5

Question: Rate the adequacy of E-8 O&C/GSM console in displaying FTI radar data

Response: Total-5. Very effective 3/5 Somewhat effective 1/5 Borderline 1/5

Question: Rate the effectiveness of the E-8 O&C/GSM console in displaying map-like features (terrain, roads, and other cartographic data) while in the MTI mode of operation

Response: Total-4. Extremely effective 1/4 Very effective 1/4 Somewhat effective 1/4
Somewhat ineffective 1/4

Question: Rate the effectiveness of the E-8 O&C/GSM console in displaying map-like features (terrain, roads, and other cartographic data) while in the FTI mode of operation

Response: Total-3. Extremely effective 1/3 Very effective 2/3

MOP 16 SAR integration function time

Post risk reduction, we determined that the SAR integration time is a developmental test (DT) measure and not OT. The SAR integration time for OT is a function of how long the airborne target surveillance supervisor (ATSS) sits on a SAR request before sending it to the system management officer (SMO) and how long the SMO sits on the request before granting it. Any data gathered for this as OT measure will be irrelevant since the wait time for a SAR could be anywhere from 1 minute to 30 minutes or even longer. As a DT measure, the integration time would begin from the time the SMO approved a SAR until the time it was produced. Since this is a set parameter based on the platform that VSTARS is running on, it was measured during the DT and will not change for the OT.