
Accreditation Issues for Verification and Validation of The Prototype Federation for the Joint Synthetic Battlespace

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Lt Col Emily Andrew
ESC/CXC

Dr. Gerald Prichard
Dynetics, Inc.

Jeffrey W. Wallace
Envoytek, Inc.



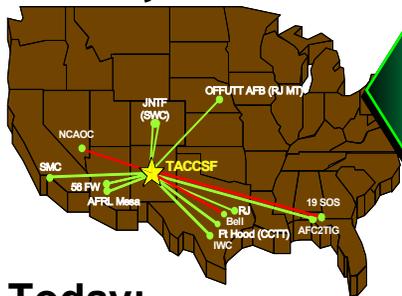
U.S. AIR FORCE

Outline

- **JSB Background**
- **JSB Experiment**
- **Functional Allocation**
- **JSB VV&A Objectives**
 - “Pathfinder”
 - Near-Term
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- **Benefits of VV&A for JSB**
- **JSB VV&A Progress**
- **Key JSB VV&A Issues**
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- **CSE Unit Test Results**
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Joint Synthetic Battlespace

**Operator
Training, Planning,
Rehearsal, . . .**



Today:

Unable to Fully Understand
Operational Impacts in a Heavily
Vegetated Environment
--Camouflage, Hyper-spectral, ...

Future:

Able to Understand Operational
Impacts in all Environments

Joint Synthetic Battlespace



A Common Architecture That:

- Represents the Natural Environment Realistically
- Verified or Physics-Based Models
- Allows Integration of Legacy Simulations

**ACQUISITION
S&T, R&D, T&E, . . .**

Government Sites
Contractor Sites



Today:

Unable to Fully Understand
System of Systems and
Environmental Impacts

Future:

Simulations Readily Available to
Assess System Complexities

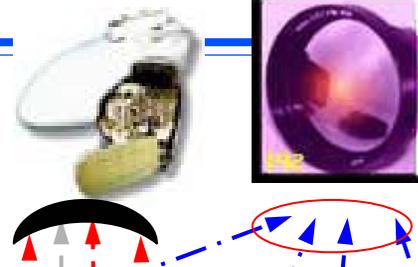
**Product: Easily Integrate-able and Persistent M&S Components
That are Reused for User Executions with High Confidence and
Comparable/Repeatable Results**

Background

- **Experiment Effort Initiated June 2001**
 - **How Experiment Fits into Overall JSB (SBA) Effort**
 - **Prototype Federation to Elicit JSB (SBA) Requirements - JOint Synthetic battlespace Experimental Federation (JOSEF)**
 - **Proof of Concept w.r.t. providing a high fidelity common synthetic environment to service battlespace entities**
 - **What's Different about the Experiment**
 - **Common Synthetic Environment driving three separate sensor simulations on the Rivet Joint, JSTARS, UAV, and F-15E platforms**
 - **Traversing mixed mode Synthetic Environment -- integration of high fidelity postage stamp (~nn square meters) into JCIET low fidelity play box**
 - **Mixed resolution w.r.t. physics based models of the three separate sensor simulations -- Prophet, ACS, and PRISM**



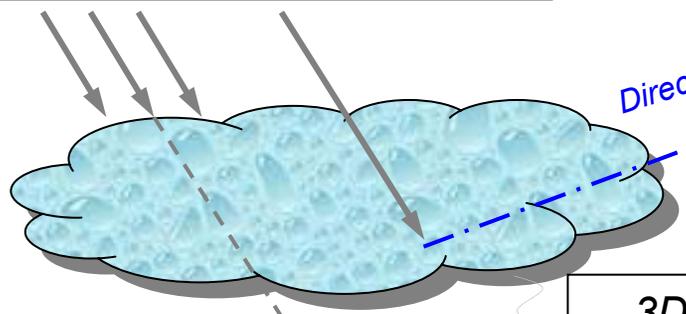
JSB CSE for At-aperture EO/IR/RF Signatures



Attenuated, refracted directional EO/IR passband radiance (LANTIRN & EO)

Attenuated refracted RF signal (MTI, SAR & ELINT)

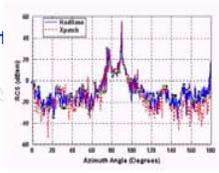
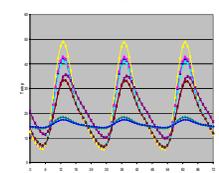
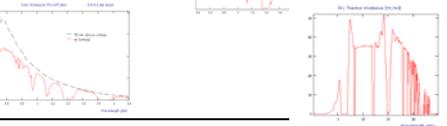
Full, Hi-Res Spectral Solar/Lunar/Star/Sky/Manmade Irradiances



Direct Reflected Passband Irradiance

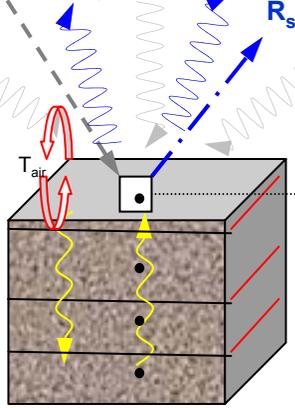
3D Gridded Atmosphere

Scattered & Attenuated Direct & Diffuse Spectral & Atmospheric

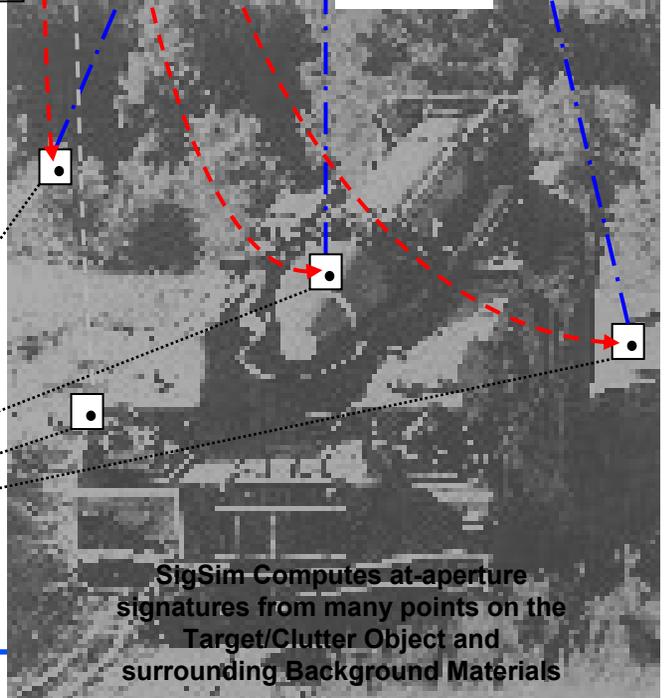


EO/IR/RF Signature Synthesis

- Material Systems assigned to DB&Target Objects
- Spectral BRDF directional radiance
- 1D Transient Thermal Model, (Diurnal cycle, solar loading, conduction, convection, radiative cooling, dynamic vehicle states)
- RCS (σ) and Background σ_0



T_{surf}
 $R_{surf}(az, el, \lambda)$
 $\sigma(az, el, f)$ or
 $\sigma_0(az, el, f)$ or
 Emitter Power



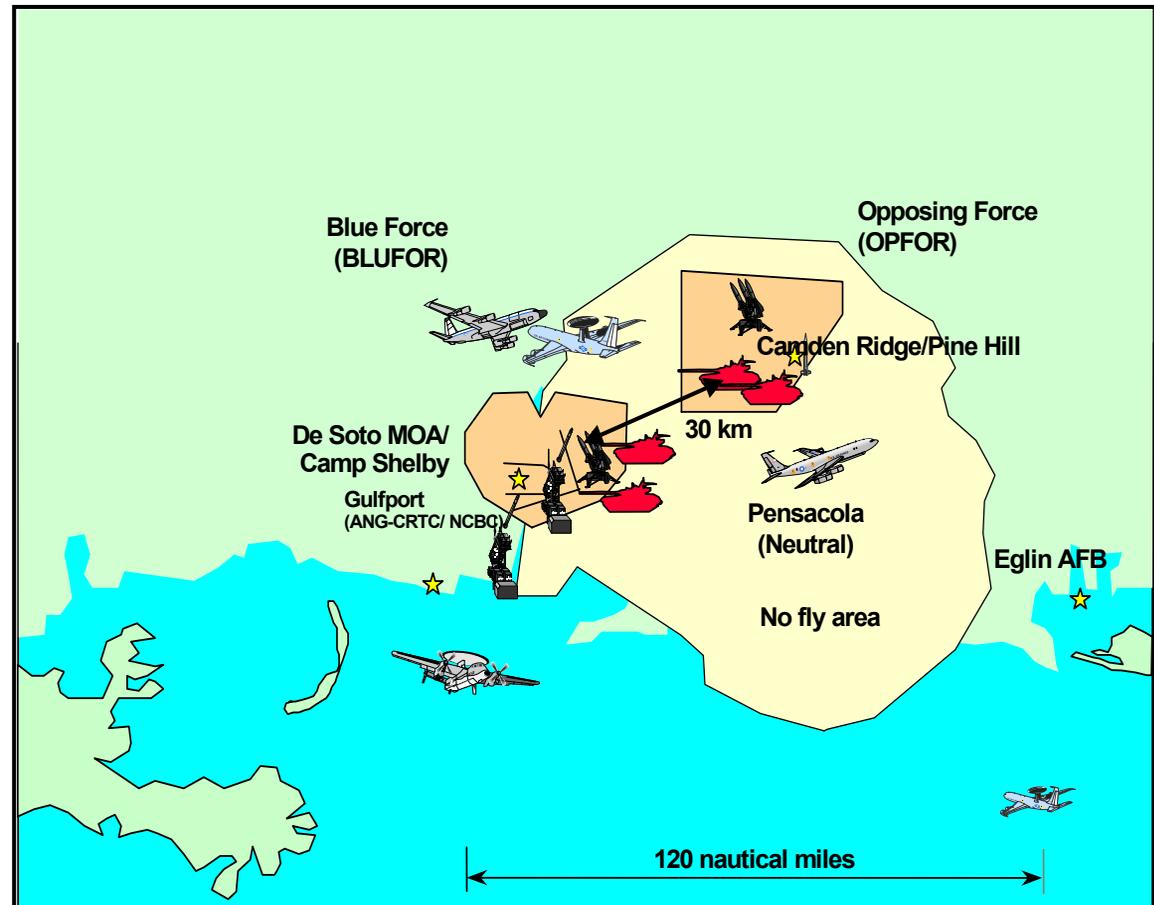
SigSim Computes at-aperture signatures from many points on the Target/Clutter Object and surrounding Background Materials

JSB Experimentation - FY02

Prototype, Requirements, Validate, Gain Insight

JSB Spring 02

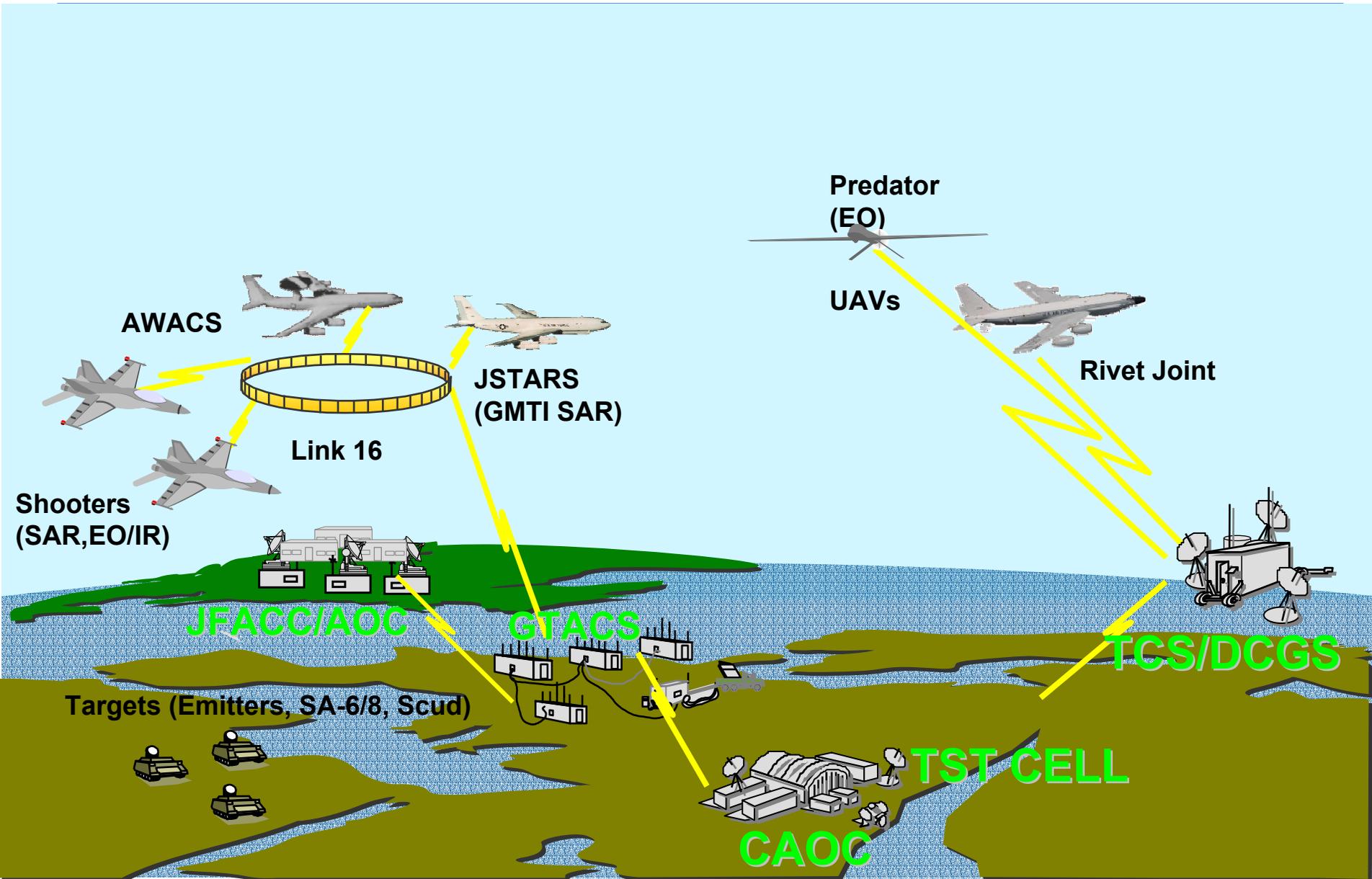
- Build JSB Prototype Based on JCIET/JC2ISR 2002 Live Event
 - Capability to Evaluate TCT, JCAS, C2ISR Deep and Close Targets
- Validate Synthetic Environment with Live-fly Data in Vegetated Scenario
- JCIET Statistics
 - Over 300 Vehicles
 - Fully instrumented
 - 4,000 Participants
 - Joint & Coalition
 - Live Fly 15-26 April 2002
- Demonstrate Future Mission Rehearsal Application



Completed JSB Prototype 0 – RF, SAR, GMTI Interactions

Challenge -- Leverage Activities and Funding from Multiple Sources to Prototype JSB Architecture & Perform V&V

JSB Experiment Operational Architecture



Functional Allocation

Model Suite

	JSAF	PRISM	ACS	CORE	Prophet	SigSim	OASES
Rivet Joint							
<i>Platform</i>	LM-IS						
<i>SIGINT</i>					CACI		
<i>Operators</i>				BRC			
<i>INS/GPS</i>	LM-IS						
<i>Voice</i>	LM-IS						
JSTARS							
<i>Platform</i>	LM-IS						
<i>GMTI SAR</i>			NG-ES				
<i>Operators</i>				BRC			
<i>INS/GPS</i>	LM-IS						
<i>Link 16</i>	LM-IS						
<i>Voice</i>	LM-IS						

Functional Allocation (cont'd)

	JSAF	PRISM	ACS	CORE	Prophet	SigSim	OASES
F-15E							
<i>Platform</i>	LM-IS						
<i>APG-70</i>			NG-ES				
<i>LANTIRN</i>		LM-					
<i>Operators</i>		MFC		BRC			
<i>INS/GPS</i>	LM-IS						
<i>Voice</i>	LM-IS						
<i>Link 16</i>	LM-IS						
Predator							
<i>Platform</i>	LM-IS						
<i>EO Sensor</i>		LM-					
<i>Operator</i>		MFC		BRC			
<i>Downlink</i>	LM-IS						
<i>Voice</i>	LM-IS						
<i>INS/GPS</i>	LM-IS						

Functional Allocation (cont'd)

	JSAF	PRISM	ACS	CORE	Prophet	SigSim	OASES
TST Cell							
<i>Staff</i>				BRC			
<i>Link 16</i>	LM-IS						
<i>Voice</i>	LM-IS						
CSE Service							
<i>Geospatial Interrogation</i>	LM-IS						
<i>EO/IR Propagation</i>						JRM	
<i>RF Propagation</i>						JRM	
<i>Signature Synthesis</i>						JRM	
EnviroFed Components							
<i>Atmosphere EO/IR/RF</i>							NG-IT
<i>Operator</i>				BRC			

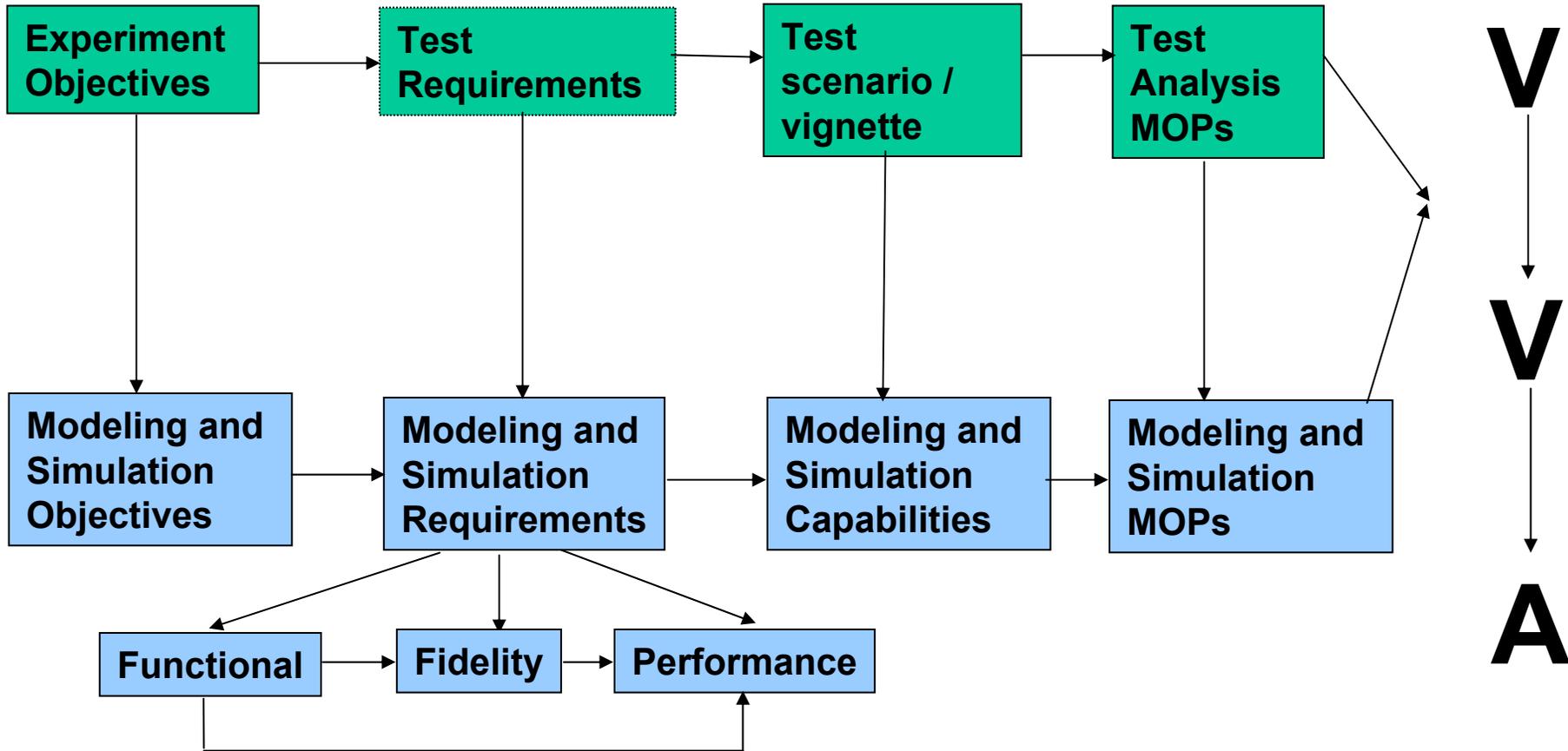
JSB VV&A Objectives (“Pathfinder”)

- **Implement VV&A as a life-cycle activity for simulation-based acquisition**
 - Assist in the refinement of the JSB requirements and future experiments
 - Quantify actual simulation results to assess status and risk for future development and experiments
- **Provide clear traceability from the JSB Objectives to all levels of VV&A performed**
- **Provide for data archival capabilities, especially for data collected and analyzed from Experiments**

JSB VV&A Objectives (Near-Term)

- **Emphasis of VV&A for near-term is accreditation assessment**
 - Focus is on comparisons of collected data from the Joint Combat Identification and Evaluation Team (JCIET) operational scenarios with corresponding simulation runs from the JSB Spring Experiment 2002.
- **Focus of simulation runs will be on measures of performance (MOPs) relative to sensor model outputs**
 - Inputs provided by and determined from the Common Synthetic Environment (CSE) Service.
- **Accreditation guides verification/validation activities**
- **VV&A Plan (for experiments and for “Pathfinder”)**

VV&A Overview



Benefits of VV&A for JSB

- **Provide traceability using quantifiable measures of performance in comparing actual “live-fly” test data and simulation data**
- **Provide independent technical analysis of JSB simulation efforts**
- **Use quantifiable results of Experiments to guide overall JSB requirements, especially with regard to simulation-based acquisition**

Benefits of Early VV&A Involvement in Federate Development

- **Provided opportunity to confirm validity impact from potential issues such that they could be addressed early in the development cycle.**
 - **CTDB flat-earth compiler; Dead Reckoning**
- **Provide opportunity for VV&A agent to suggest program features and changes to facilitate the VV&A process**
 - **Time-step ordering**
- **Provide opportunity to identify specific data requirements for the test data and the simulated data**
 - **JCIET test data**
 - **Inter-federate and Intra-federate data**

JSB VV&A Progress

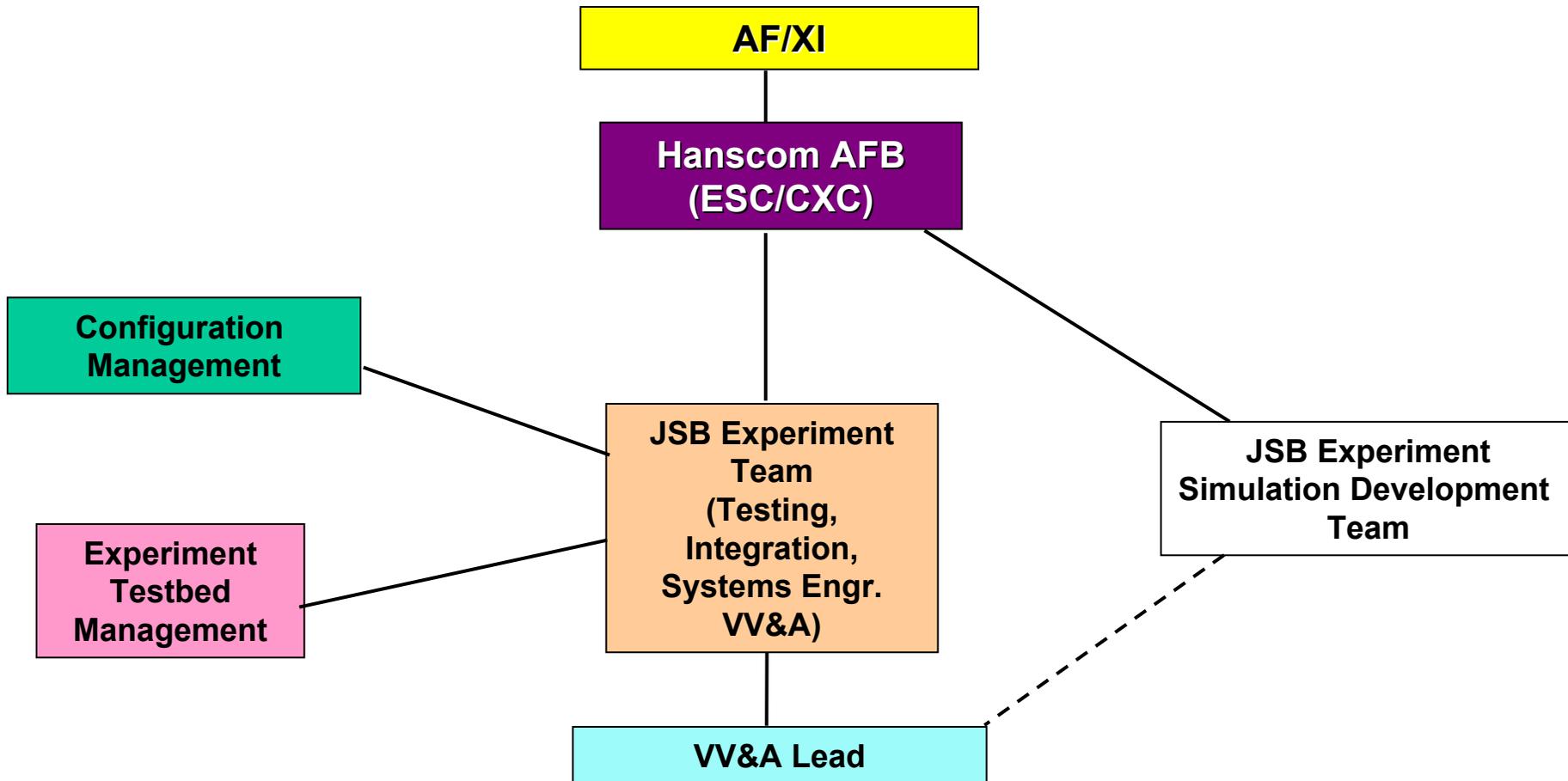
- Developed MOEs/MOPs
- Developed Data Collection Plan
- Collected the VV&A histories of the JSB Experiment Components
- Performed an analysis of the JCIET data to identify “good” vignettes
- **Establishing that the fundamental quantities in the CSE are following the correct trends and the values are reasonable***
- Begin rigorous VV&A after the completion of Experiment 1 in Q1 of FY03

***Current Status**

Key JSB VV&A Issues

- **Time mgt. for the sensor models and Common Synthetic Environment (CSE) service are key to repeatability and hence validation, given the focus of the MOPs on timing.**
- **Validation history of models is incomplete (no federate-level V&V For JOSEF, but is planned in general).**
- **Need to determine if SOMs and FOMs being used for the HLA Federation have test drivers built to address the volume and rate of data necessary to address real-time detections.**
- **Data collection mechanisms (localized versus central) to capture federate-specific data is a V&V issue.**
- **Accreditation focus for federation-level assessments with “live” test data implies limited validation (in its traditional usage)**

JSB VV&A Participants

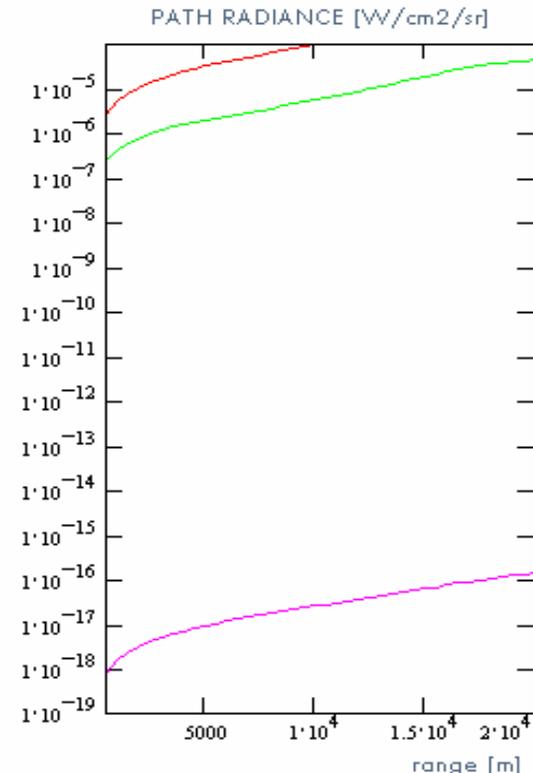
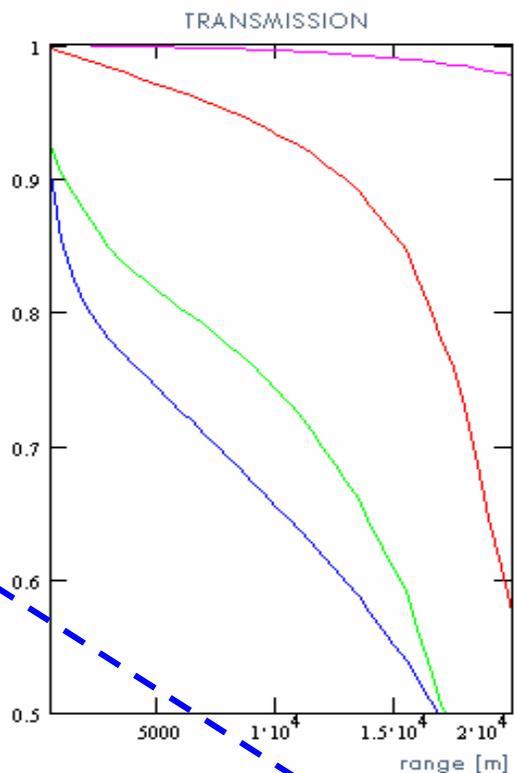


----- Dotted line indicates VV&A is independent of development team, though VV&A Lead does participate with developers to assess impact of simulation design and architecture upon VV&A.

CSE Unit Test Results

- **Tests were performed in a static execution environment (i.e., not integrated into the JSB Experiment Federation)**
- **Establish that the most complex software component in the JSB Experiment Suite is operating as expected**
- **Verify correct trends in terms of signature generation and signal propagation**
- **Ensure that correlation exists across all spectrum components of interest**
- **Verify correct trends with respect to weather, vegetation, and types of clutter**

JSB CSE Correlated Spectral Band Atmospheric



- 0.2-0.7 micron
- 3-5 micron
- 8-12 micron
- 29995-30005 micron

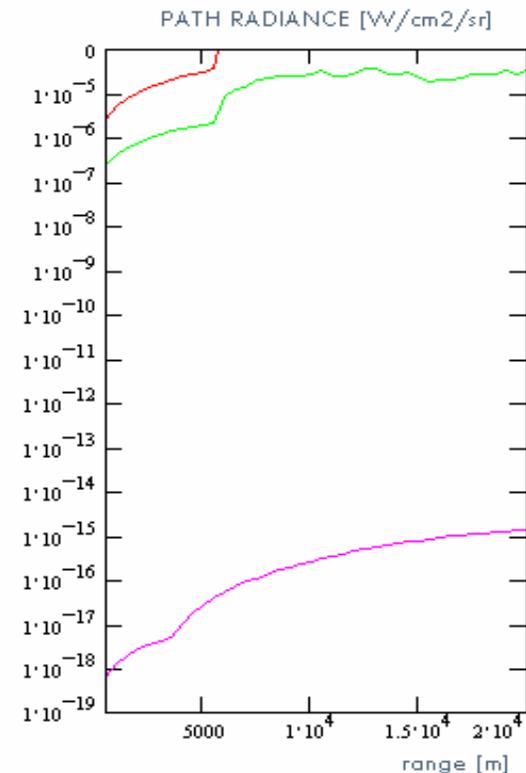
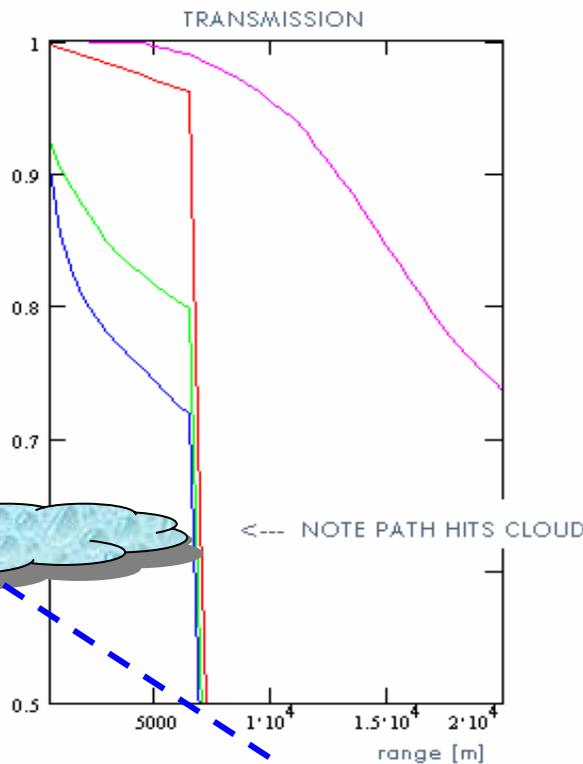
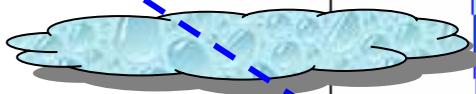
- 0.2-0.7 micron (< 10E-19)
- 3-5 micron
- 8-12 micron
- 29995-30005 micron

path : 30 degrees from horizontal at 10km
 Weather : mid-latitude summer, no rain,
 50% relative humidity

**Correct trends
 observed
 across all
 spectrum
 components
 of interest**



JSB CSE Correlated Spectral Band Atmospheric



- 0.2-0.7 micron
- 3-5 micron
- 8-12 micron
- 29995-30005 micron

- 0.2-0.7 micron (< 10E-19)
- 3-5 micron
- 8-12 micron
- 29995-30005 micron

path : 30 degrees from horizontal at 10km

Weather : mid-latitude summer, 20mm/hr rain,
90% ave relative humidity

**Correct trends
observed
across all
spectrum
components
of interest**

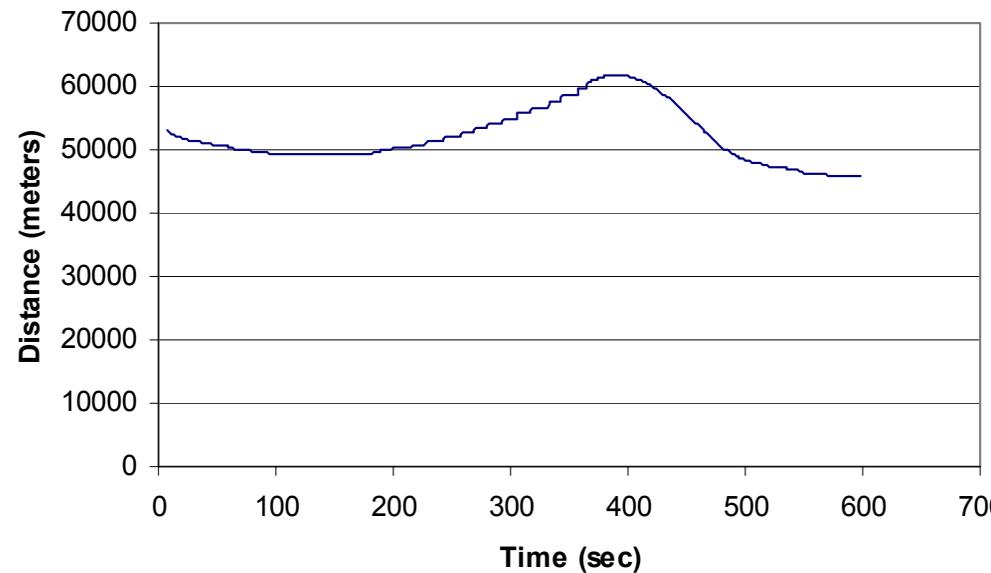
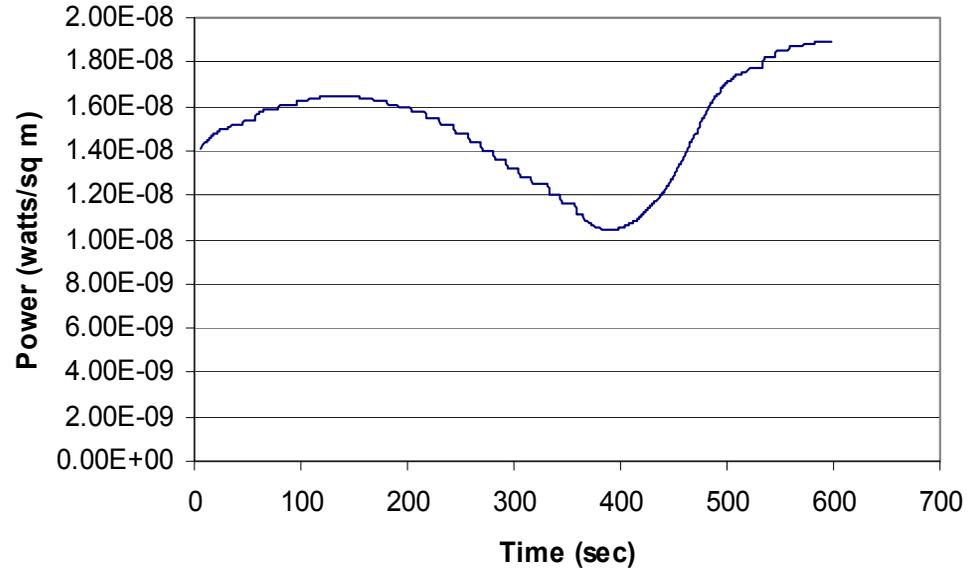


Integration Test Results

- **Performed using the JSB Experiment 0 Federation Suite:**
 - **Common Synthetic Environment (CSE)**
 - **Ocean and Atmospheric Synthetic Environment Service (OASES)**
 - **Publisher**
 - **Time-federate**
 - **Subscriber**
 - **Joint Semi-Automated Forces (JSAF)**
 - **ClutterSim**
 - **Rivet Joint SIGINT Sensor Suite (COMINT, ELINT)**
 - **JSTARS MTI/SAR Radar**
 - **JSTARS Operator Model**
 - **Time Sensitive Targeting (TST) Cell Model**
 - **Data Collector**
 - **Simulation Viewer (Sview)**
- **Verify that the trends observed in Unit Testing are observed when run using the whole suite**
 - **Correct trends in terms of signature generation and signal propagation**
 - **Correct trends with respect to weather, vegetation, and types of clutter**

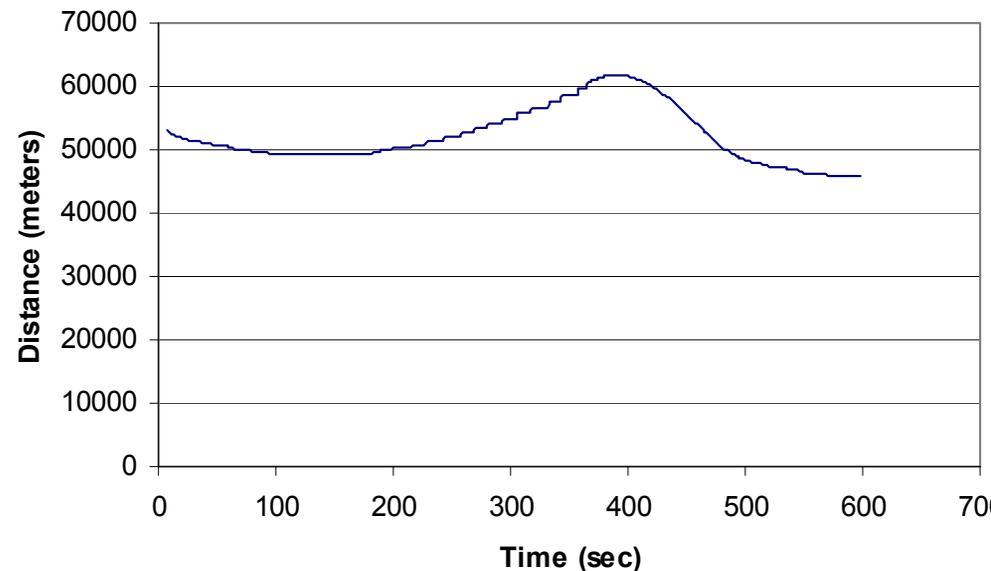
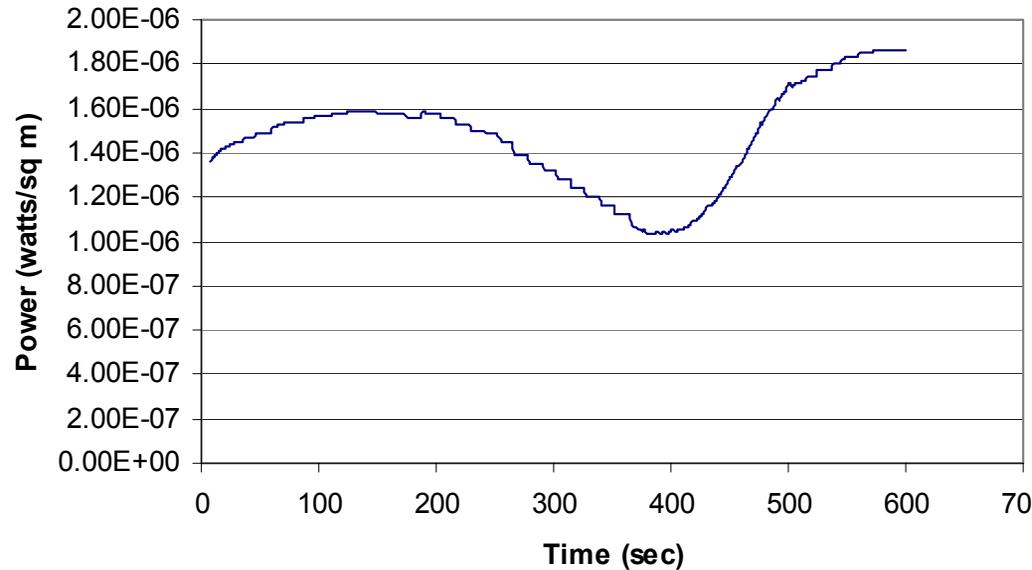
Attenuated Power at the Rivet Joint COMINT Sensor Antennae

- **Emitter:**
 - 500 Watt radio
 - 338 MHz operating frequency
- **Values correlate with known test cases**
- **Correct behavior observed with respect to distance between the target and the Rivet Joint platform/sensor**



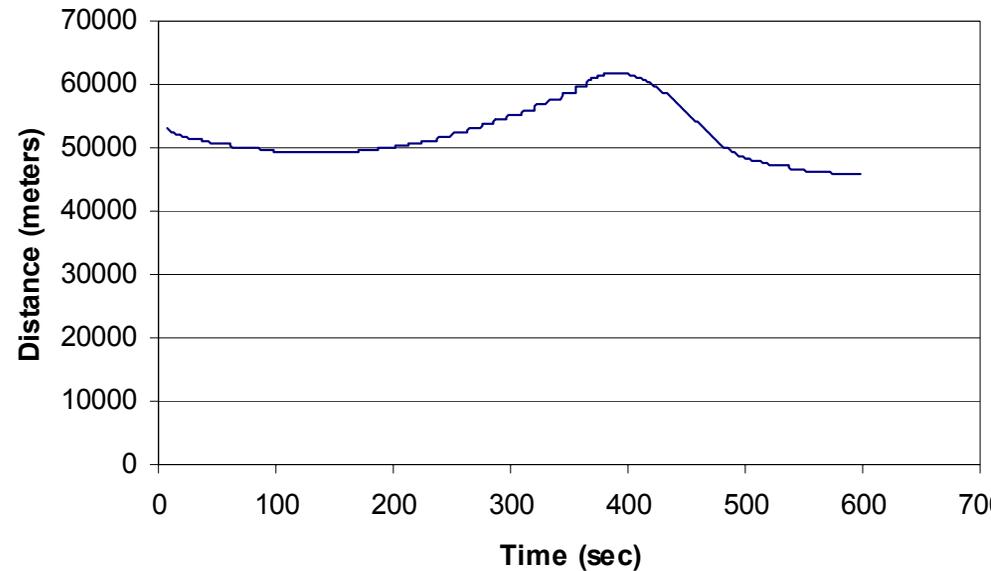
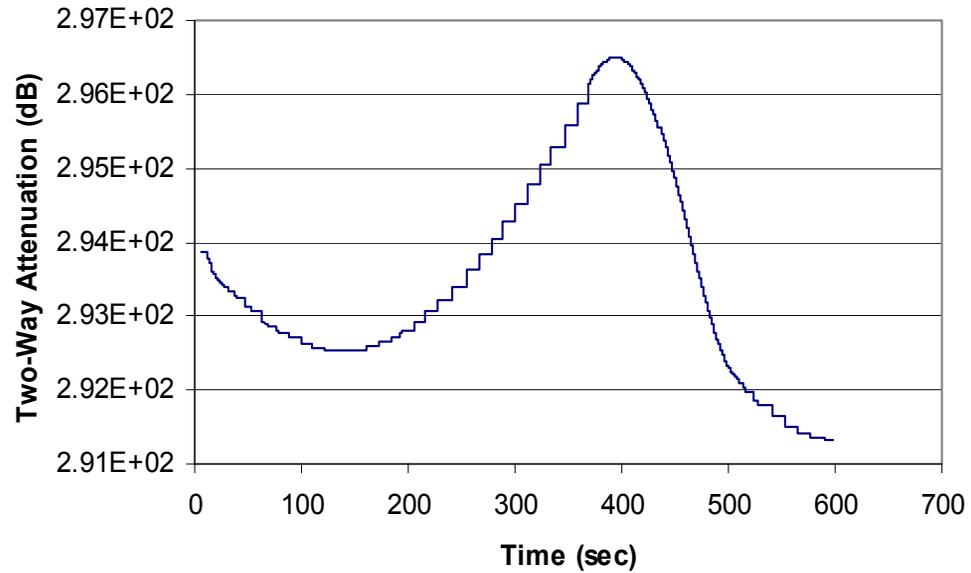
Attenuated Power at the Rivet Joint ELINT Sensor Antennae

- **Emitter (SA-6 Fire Control Radar):**
 - 5000 Watts Power
 - 7.9 GHz operating frequency
- **Values correlate with known test cases**
- **Correct behavior observed with respect to distance between the target and the Rivet Joint platform/sensor**



Two-way Attenuation of JSTARS SAR/MTI Radar

- **Target: SA-6 Fire Control Radar**
- **Values correlate with known test cases**
- **Correct behavior observed with respect to distance between the target and the JSTARS platform/sensor**



Future Directions

- **Complete the JSB Experiment 1 and 1a**
- **Complete the JSB Experiment VV&A package**
- **Consider the impact of the process on the VV&A of component aggregations**
- **Provide feedback on tool support for VV&A processes**
- **Provide feedback to components developers on the maintenance of VV&A histories to facilitate the VV&A of inclusions into highly composite federates**

Back-up slides

MOE 1 (Capability to Detect) Calculations

Notation:

k = A/C index, $k=1, \dots, K$

i = target index, $i=1, \dots, I$

m = minute index, $m=1, \dots, M$

J_{kim} = number of attempts to detect the i^{th} target in the m^{th} minute, by the k^{th} A/C

j = sensor attempt to detect, $j=1, \dots, J_{kim}$

$P_c(k, i, m)$ = Prob { clear LOS from k^{th} A/C to i^{th} target in the m^{th} minute }

$P_{d/c}(j, k, i, m)$ = Prob { detect i^{th} target in the m^{th} minute with the j^{th} attempt from the k^{th} A/C given clear LOS }

$P_d(i, m)$ = Prob { detect i^{th} target in the m^{th} minute }

$$P_d(i, m) = 1 - \prod_{k=1}^K \left\{ 1 - P_c(k, i, m) \left[1 - \prod_{j=1}^{J_{k,i,m}} [1 - P_{d/c}(j, k, i, m)] \right] \right\}$$

$$MOE\#1 = \frac{\sum_{m=1}^M \sum_{i=1}^I P_d(i, m)}{\# \text{ of detection opportunities}}$$