Test Technology Symposium 2003
Virtual Communication Links

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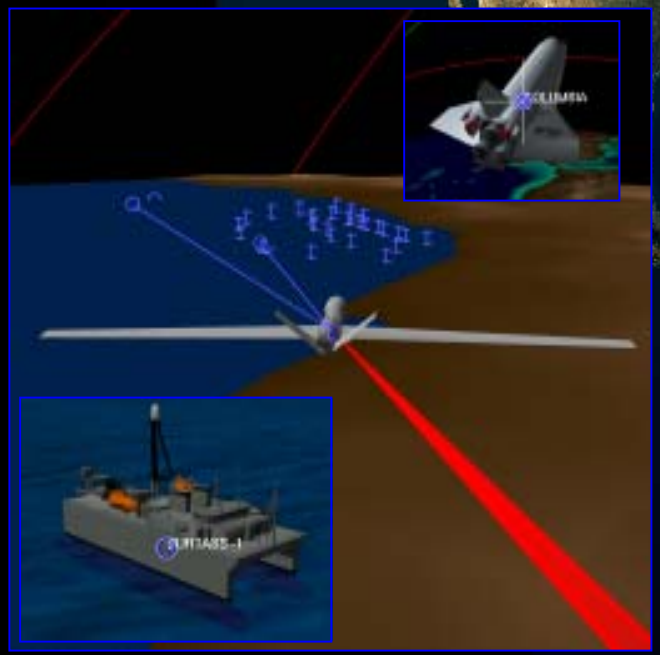

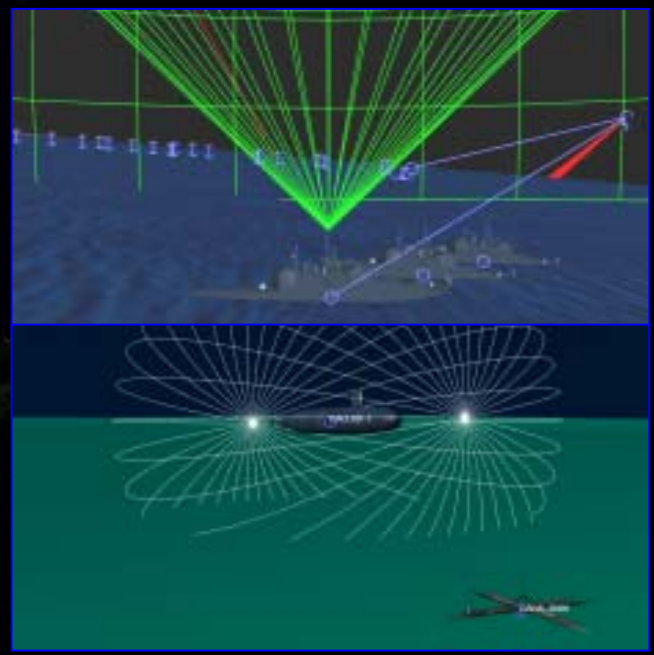

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ADVANCED VIRTUAL INTELLIGENCE SURVEILLANCE RECONNAISSANCE

High Performance Computing Modernization Program
System of Systems Simulation (SOS) Portfolio
Virtual Communication Links Project (SOS-02)

Presented To:
Test Technology Symposium
26 June 2003

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System Virtual Prototyping
Concept

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- Build virtual prototypes Army, Navy, Air Force, joint, national, NATO, coalition, and hostile systems
- Combination of real and virtual components
- Use system real hardware and software as practical
- Otherwise use virtual components
  - Targets and target signatures
  - Environment
  - Communication links
  - Not enough real components available
- Virtual components
  - Equivalent performance
  - Equivalent interfaces
  - Variable fidelity (minimum fidelity but enough fidelity)

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System Virtual Prototyping
Rationale

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- **Minimize life cycle cost**
  - Early detection and correction of problems
  - Early test with external system elements
  - Early test with warfighter in the loop
  - System field testing
    - Pre-test planning, rehearsal, and evaluation
    - Post-test replay, evaluation, and validation for future tests
- **Optimize performance**
  - Evaluate system effectiveness
  - Understand complex interactions
    - Parameter variation
    - Visual representation of non-visual effects

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System Virtual Prototyping
Rationale (continued)

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- **Mitigate risk**
  - Assets and personnel
  - Test system in hostile areas unavailable in peace time
  - Testing unobservable by hostile forces that could otherwise monitor deployment, com links, and system performance
- **Transition to operational system use**
  - Training, mission planning and rehearsal, mission effectiveness
  - Performance evaluation of system modifications

System-of-Systems Simulation

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High Performance Computers (HPCs)

Virtual Systems and Simulations (JSIMS/JSAF)

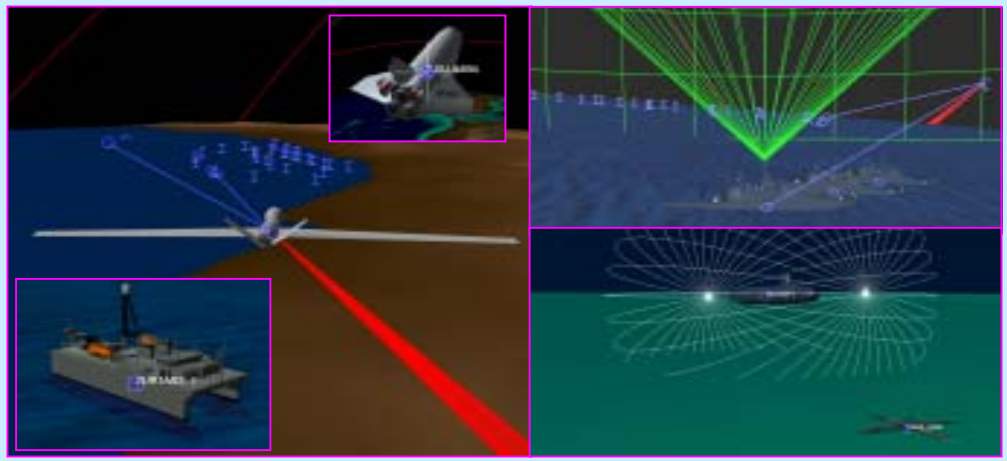
Targets	Sensors	CNI	Jam/Det	Weapons	Environ	Databases

HLA / SPEEDES

Sites

- DOD Facilities
- Training Ranges
- DEPs
- National Labs

SDREN



Visualization

- Multi-Aspect Views
- Virtual and Live Entities
- Terrain and Features
- Non-Visual Effects

Warfighters	Analysts	Engineers	Testers	Logistics	Trainers	Tacticians

Users

Concept	Develop	Test	Optimize	Cost	Train	Ops

Uses

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National Common Database Initiative

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- Navy, Army, Air Force, and other databases are stove-piped
- Install these databases on High Performance Computing (HPC) Modernization Program (HPCMP) assets
  - High Performance Computers
  - Secret Defense Research Engineering Network (SDREN)
- Databases maintained locally by their owners
- Database reflectors at remote sites provide rapid access to data
- Common interface for determining kind of data available
- Common interface for accessing the data
- Eliminate need for expensive, proprietary, difficult to manage, multiple, database managers on every computer (Oracle, Sybase, Access, FoxBASE, MySequel, Informix, etc.)
- Database Internet (availability, usability, association)

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Communications
Essential to the Battlefield

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- No C2 without communications
  - Sensor tasking
  - Sensor reports
  - Target nomination, attack decision, and weapons pairing reports
  - Attack orders
  - Battle damage assessment
- Force coordination
- Force location via electronic navigation
  - GPS
  - TACAN
  - JTIDS relative navigation
- Force identification
- Communications intelligence

Communication Effects

- Range and antenna coverage
- Terrain and feature masking, diffraction/ducting, and multipath
- Over-the-horizon and relay
- Jamming and self interference
- Bit errors and voice quality
- Network bottlenecks and bandwidth
- Message priorities, cueing, and latencies
- Environment noise
- Detection, location, and identification
- Message interception and spoofing
- Traffic analysis

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Virtual Communication Links
Project Overview

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- High Performance Computing (HPC) Modernization Program (HPCMP)
  - Common HPC Software Support Initiative (CHSSI)
  - System-of-Systems Simulation Portfolio Navy component
- Generic user-programmable communication link
- Transmitter, propagation, environment, receiver
- Communication, Navigation, and Identification (CNI) Instantiations
  - AN/ARC-164 UHF Radio
  - AN/ARC-186 VHF Radio
  - GPS User Set
  - Mark XII Identification Friend or Foe Interrogator and Transponder
- Entities and satellites
- Jammer, detector, and spectrum analyzer tools
- Defense Modeling and Simulation Office (DMSO) High Level Architecture (HLA) compliant

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ARC-164 UHF Radio

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Use	Line-of-Sight Clear/Secure Voice Communication with Push-Button Tone Capability (Morse Code or Event Indicator)
Specification	RWV-001B, Specification for Radio Set AN/ARC-164(V), 28 Feb 1978
Tuning Range	225.000 to 399.975 MHz
Tuning Step Size	25 kHz $\pm$ 2 kHz
Tuning Time	250 ms
Number of Channels	7000 with 20 Presets
Modulation	AM Voice 300 to 3500 Hz / AM Data 16.0 or 18.75 kbps Push-Button Tone at 1020 Hz $\pm$ 20%
Sensitivity	4 uV at Receiver RF Input Produces $\geq$ 10 dB (S+N)/N at the Audio Output (30% Modulation at 1000 Hz)
Transmit Power	10 Watts CW
COMSEC	KY-58 with 16 kbps CVSD Voice
Guard Receiver	243.0 MHz AM Simultaneous (Rx Mode) with Main Rx

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ARC-186 VHF Radio

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Use	Line-of-Sight Clear/Secure Voice Communication
Specification	ENAC 77-25, Technical Exhibit for Radio Set AN/ARC-186(V), 14 Feb 1980
Tuning Range	30.000 to 87.975 MHz (Tx and Rx FM) 108.000 to 151.975 MHz (Rx AM) 116.000 to 151.975 MHz (Tx AM)
Tuning Step Size	25 kHz ± 2 kHz
Number of Channels	4080 with 20 Presets
Modulation	AM Voice 300 to 3200 Hz AM Data 16.0 or 18.75 kbps FM Voice ±5 kHz with ±1 kHz Variation FM Data 16.0 or 18.75 kbps
Transmit Power	10 Watts CW, 16 Watts in FM Band
COMSEC	KY-58 with 16 kbps CVSD Voice
Guard Receiver	121.5 MHz AM Simultaneous (Rx Mode) with Main Rx

GPS

Use	Position and time determination
Method	User has 4 unknowns (3 spatial and 1 time)
	GPS provides a constellation of satellites in low earth orbit
	Time clocks on each satellite are precisely controlled
	Each satellite transmits its location and relative clock offset to universal time to the user
	User measures difference between own clock and satellite clocks (using code correlation) to 4 satellites
	4 equations and 4 unknowns allow user to solve for unknowns (position and time)
	Once user time is known, only 3 satellites are required for position determination (3 equations and 3 unknowns)
	Velocity and accelerations can be calculated from position derivatives (or lock on additional satellites)

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Mark XII IFF

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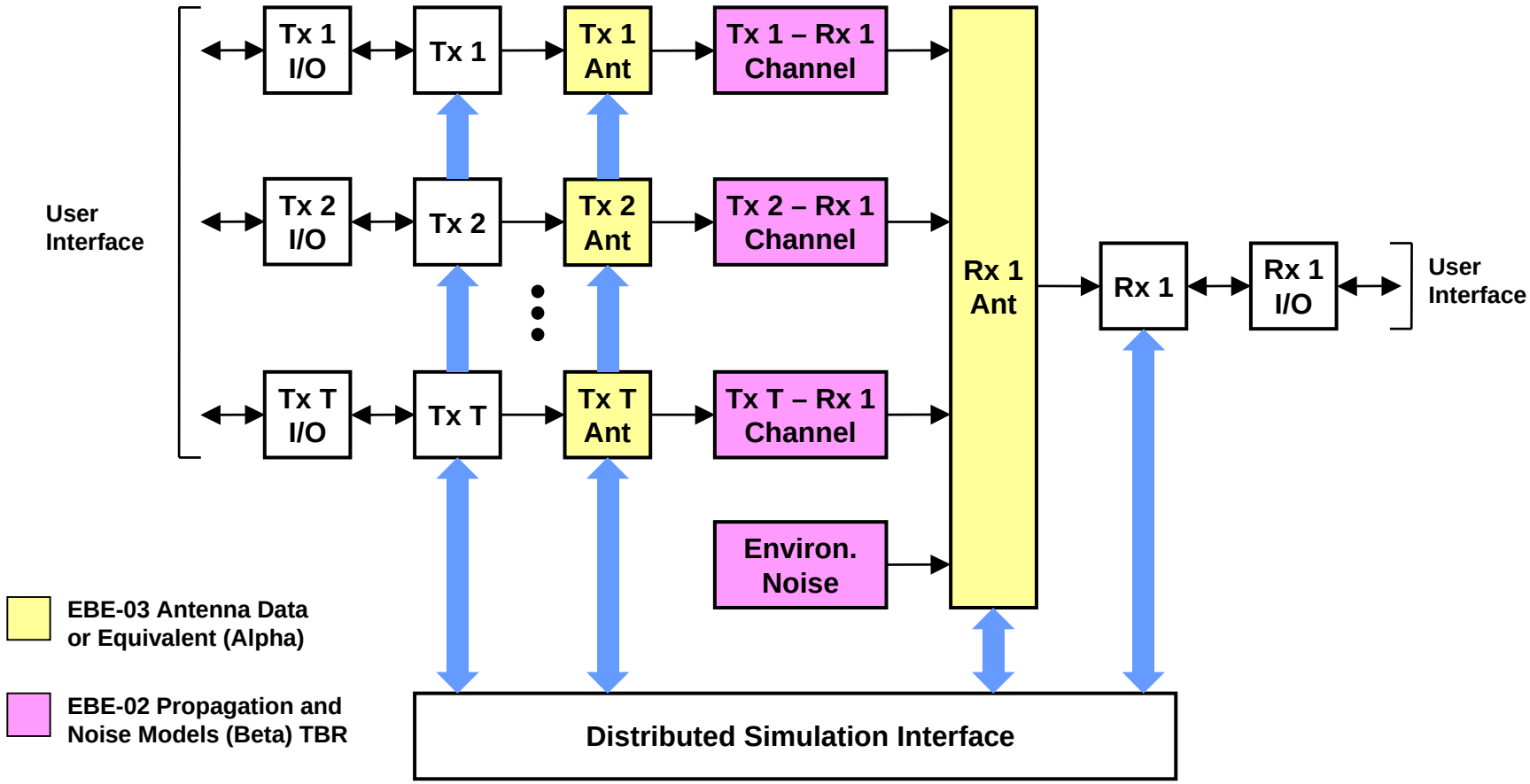
Use	Cooperative Identification Friend or Foe (IFF)
Method	Interrogator transmits challenge (radar association)
	Transponder receives challenges and transmits replies if challenges are valid
	Interrogator evaluates replies
Compatibility	International Civil Aviation Organization (ICAO) Secondary Surveillance Radar (SRR) System and Air Traffic Control Radar Beacon System (ATCRBS)
Specification	DOD AIMS 65-1000B, Performance/Design and Qualification Requirements Technical Standard for the ATCRBS/IFF Mark XII Electronic Identification System, 29 April 1983
Frequencies	Challenge: 1030 $\pm$ 2 MHz
	Reply: 1090 $\pm$ 3 MHz
Antenna Polarization	Vertical

General Radio Architecture
Tx to Rx Functional Block Diagram



HMMWV
250 MHz

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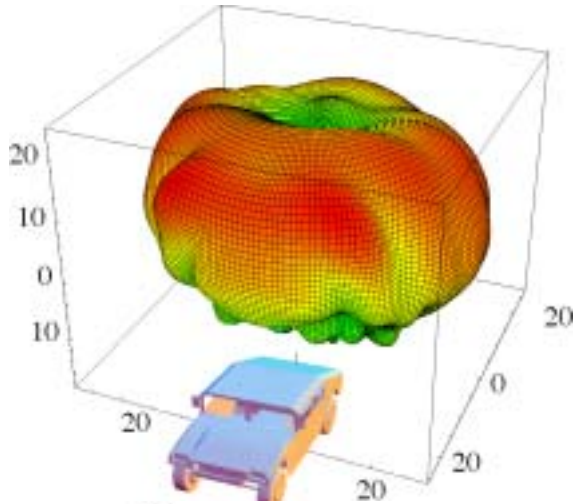
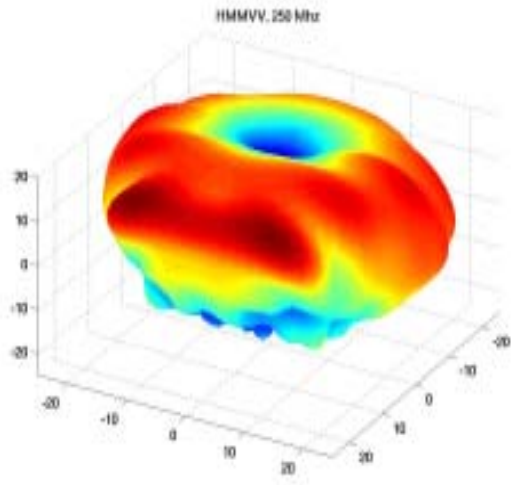
EBE-03

SOS-02 Using EBE-03 Data

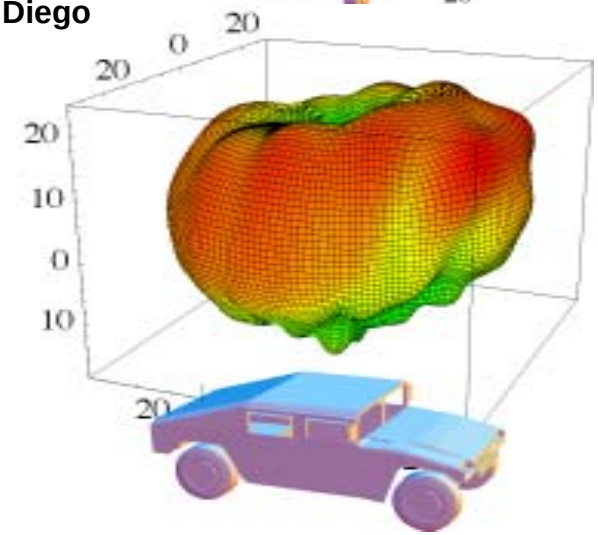
Front

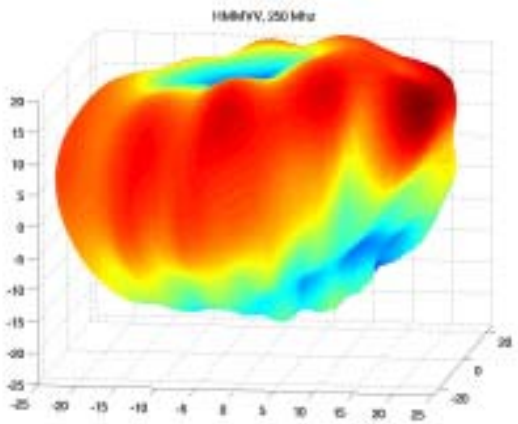




EBE-03 plots provided courtesy of Jay Rockway, SSC San Diego

Side





Notes: Gains are representative since antenna placement and type may be different from those on the actual platform. Different color scales between EBE and SOS plots.

Predator
250 MHz Bottom

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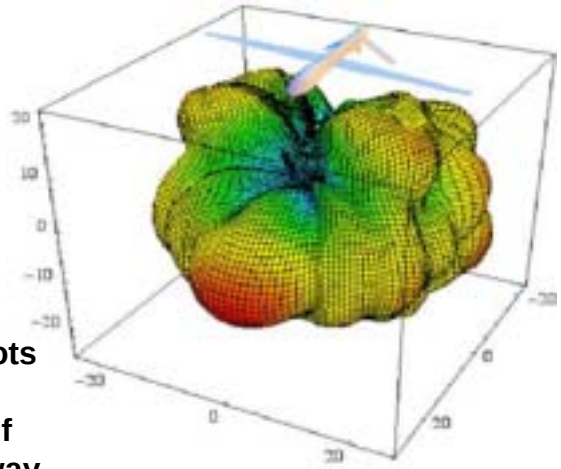
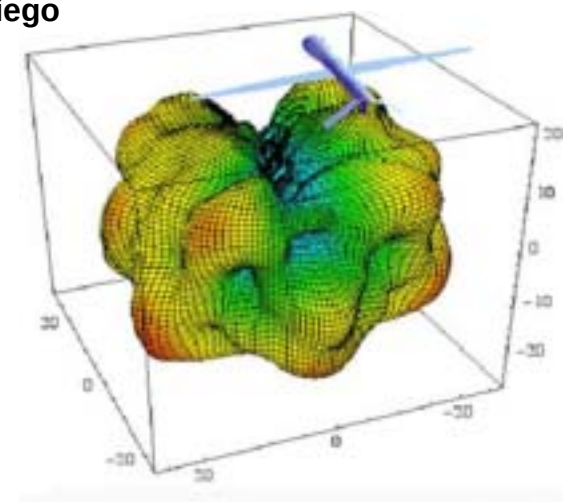
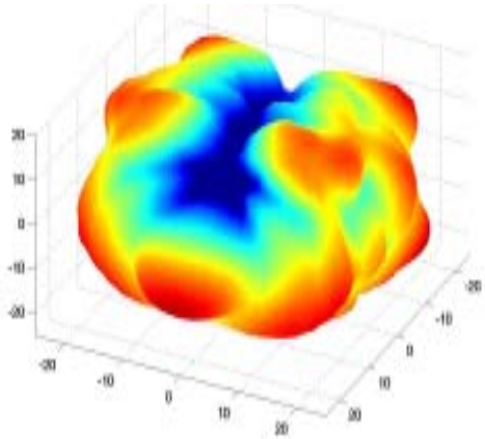
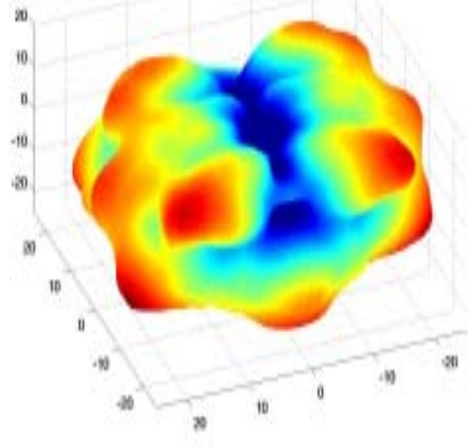
EBE-03





SOS-02 Using EBE-03 Data

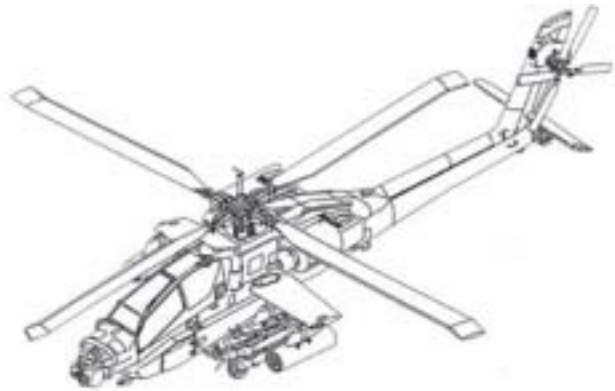




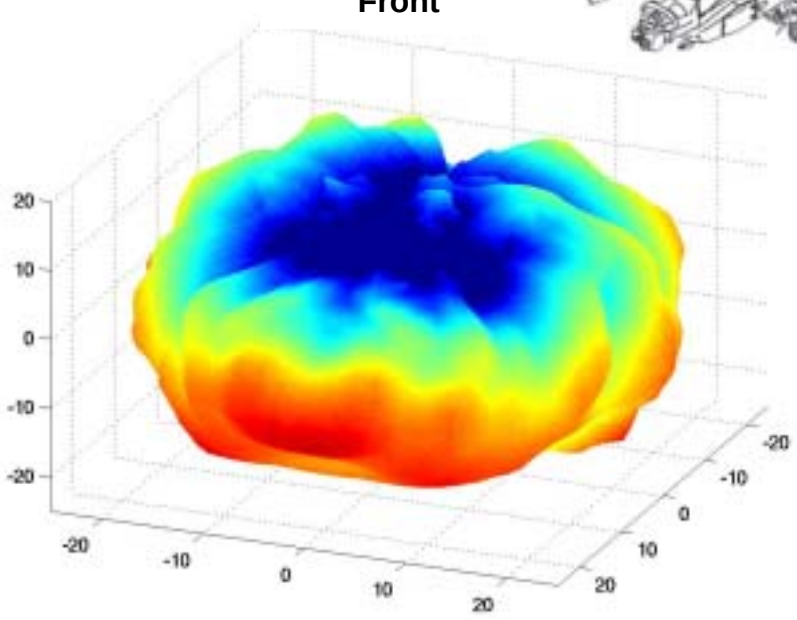
EBE-03 plots provided courtesy of Jay Rockway, SSC San Diego

Notes: Gains are representative since antenna placement and type may be different from those on the actual platform. Different color scales between EBE and SOS plots.

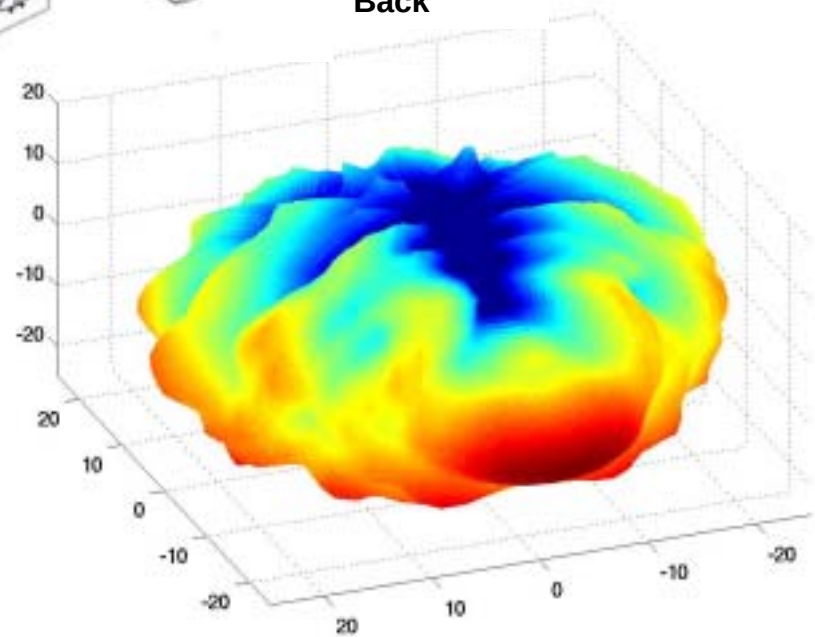
Apache
250 MHz



Front



Back



Note: Gains are representative since antenna placement and type may be different from those on the actual platform.

Apache
350 MHz

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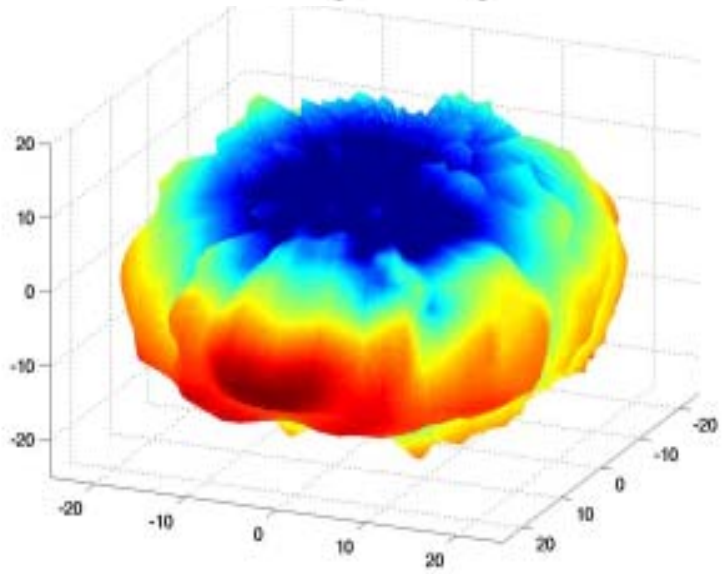
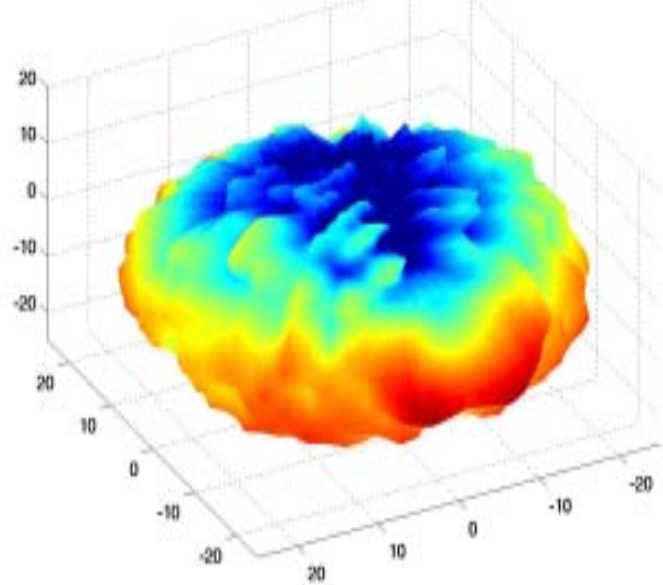
Front

Back





Note: Gains are representative since antenna placement and type may be different from those on the actual platform.

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Apache Antenna Pattern
250 MHz 3D Wire-Frame

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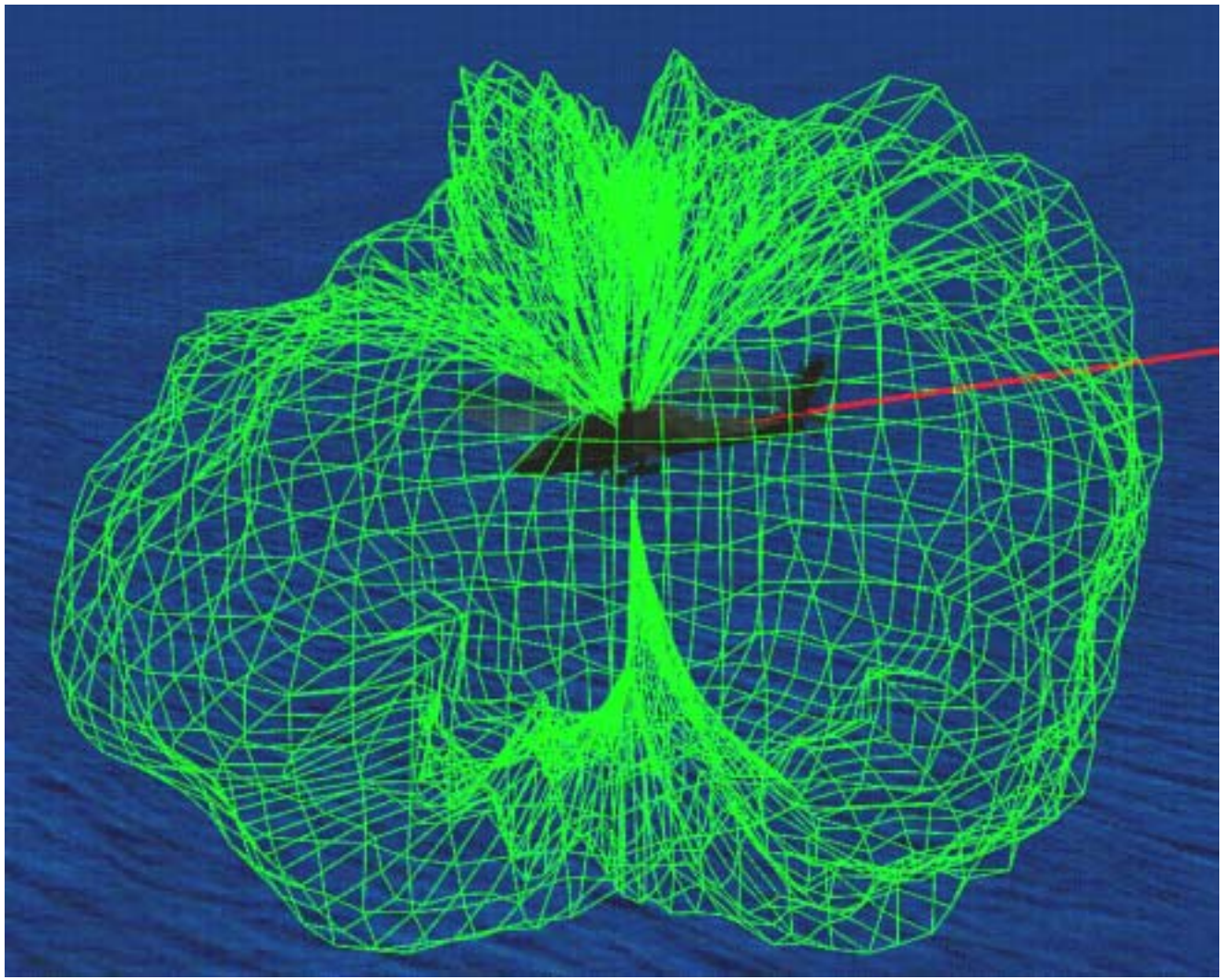

Apache Antenna Patterns

Two Entities in Simulation

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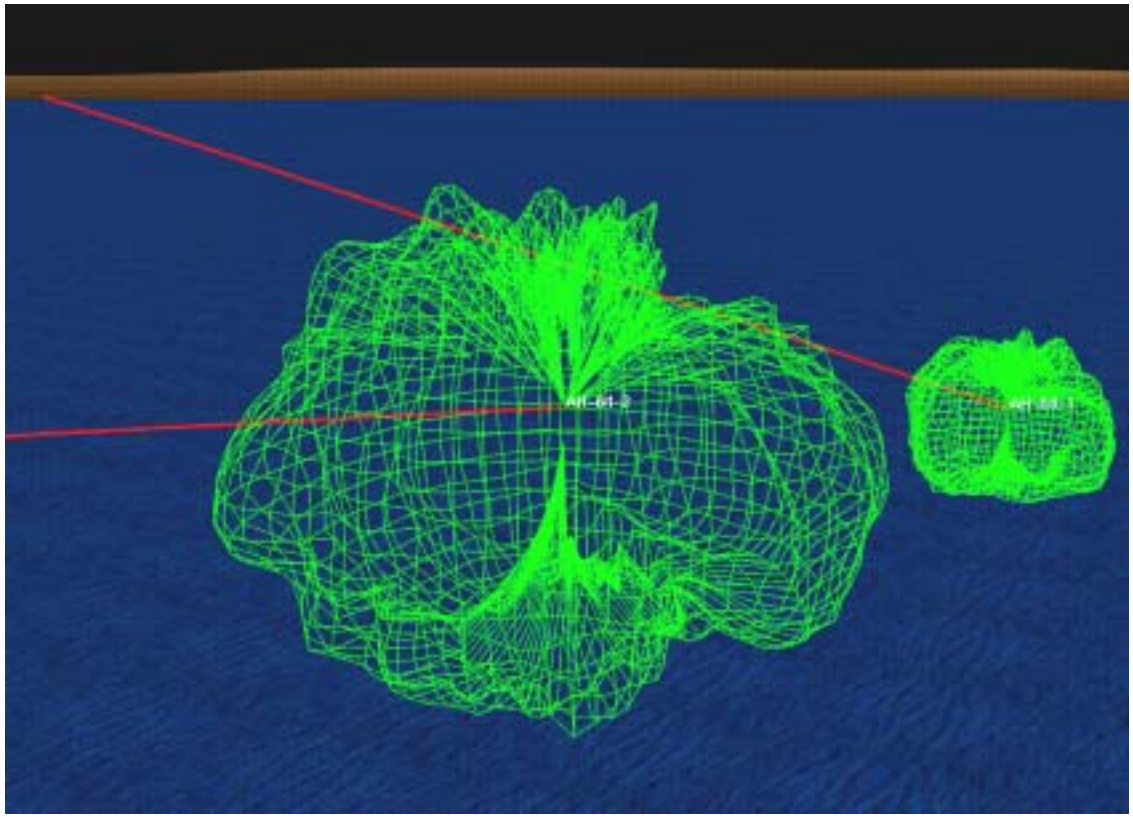

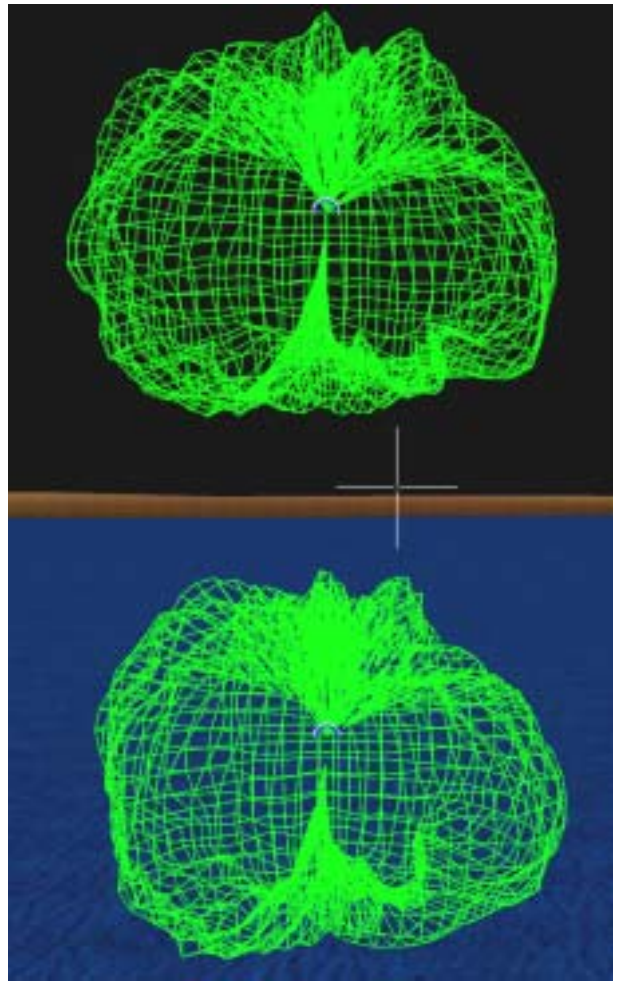

Polarization Loss
Roll-Yaw

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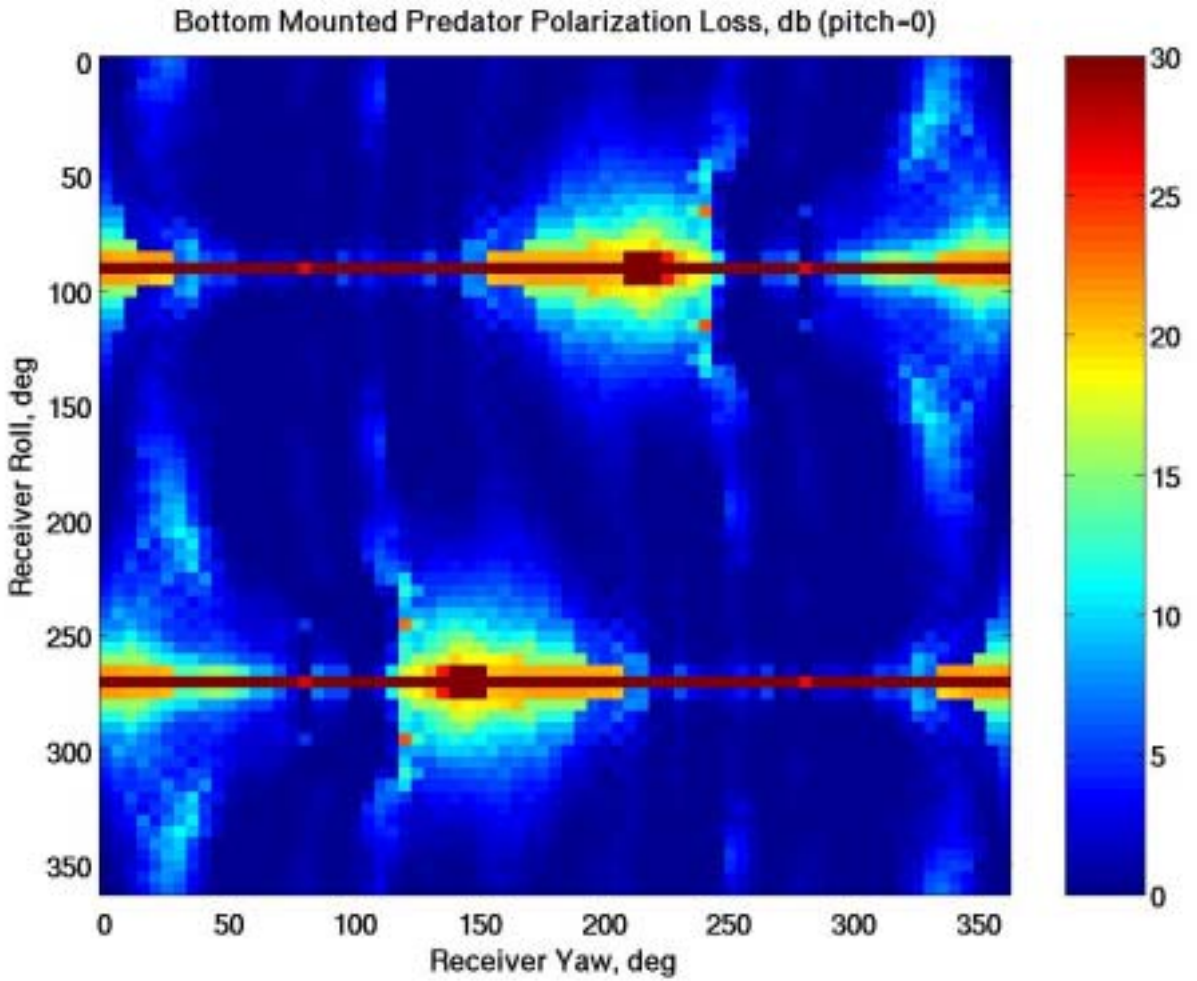

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Polarization Loss
Pitch-Yaw

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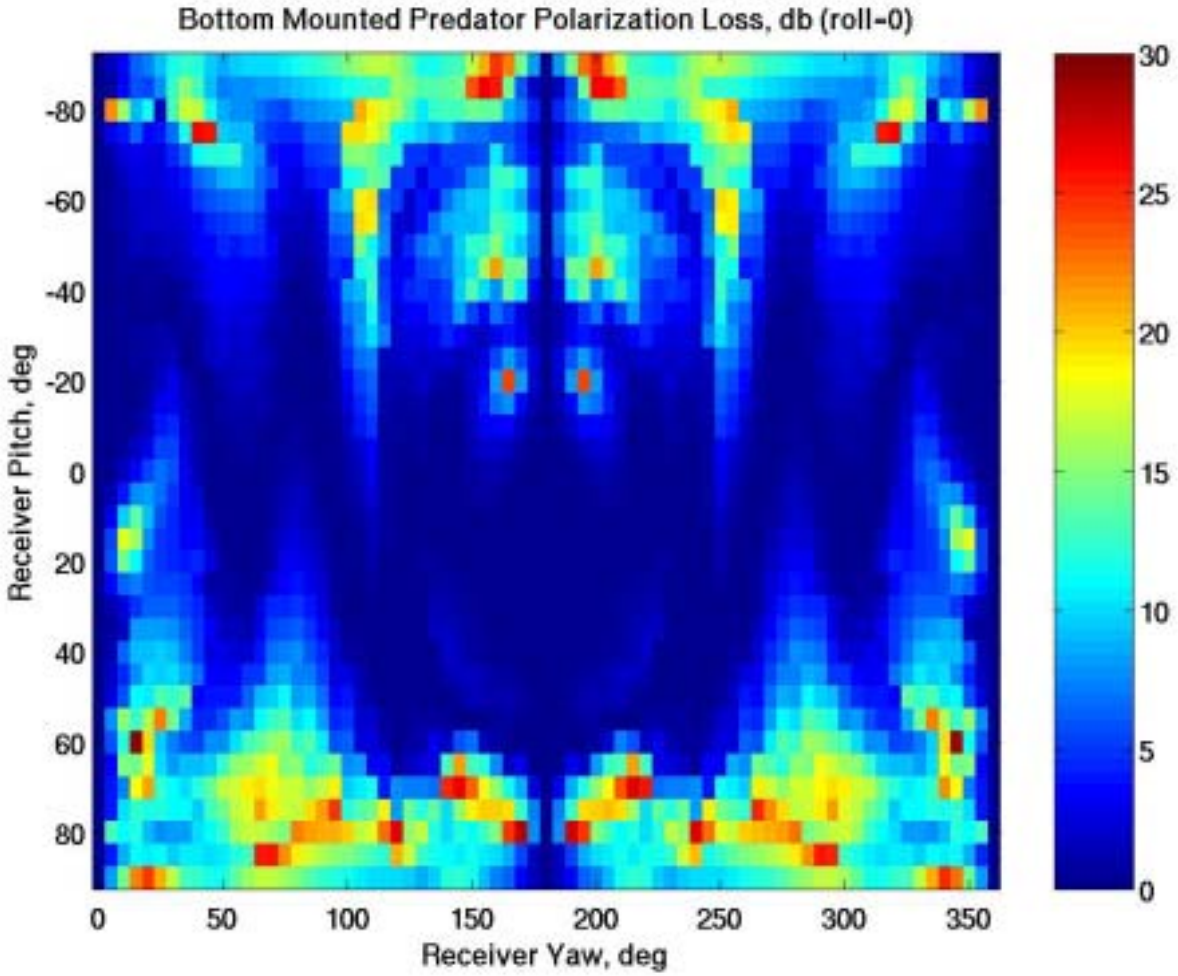
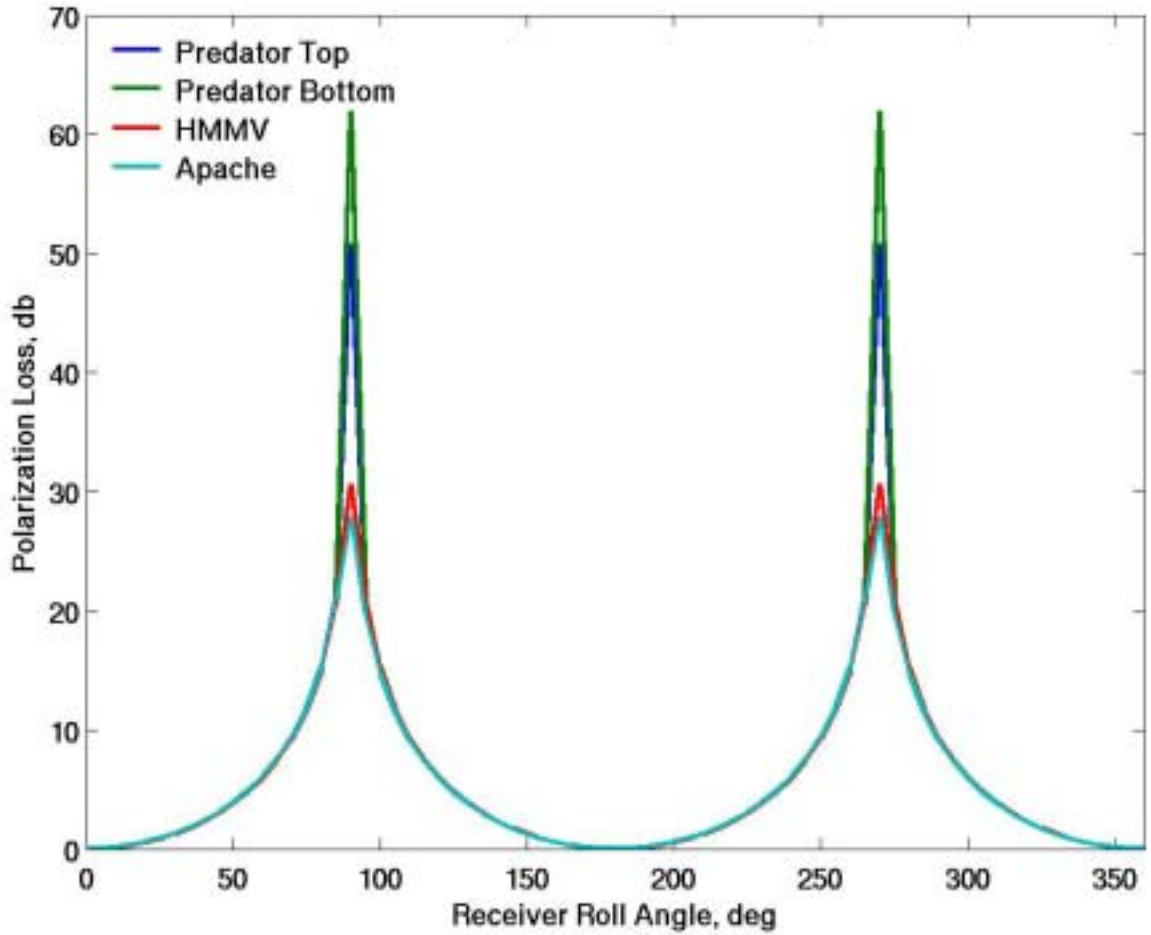


Polarization
Loss vs. Roll vs. Platform



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Link Models

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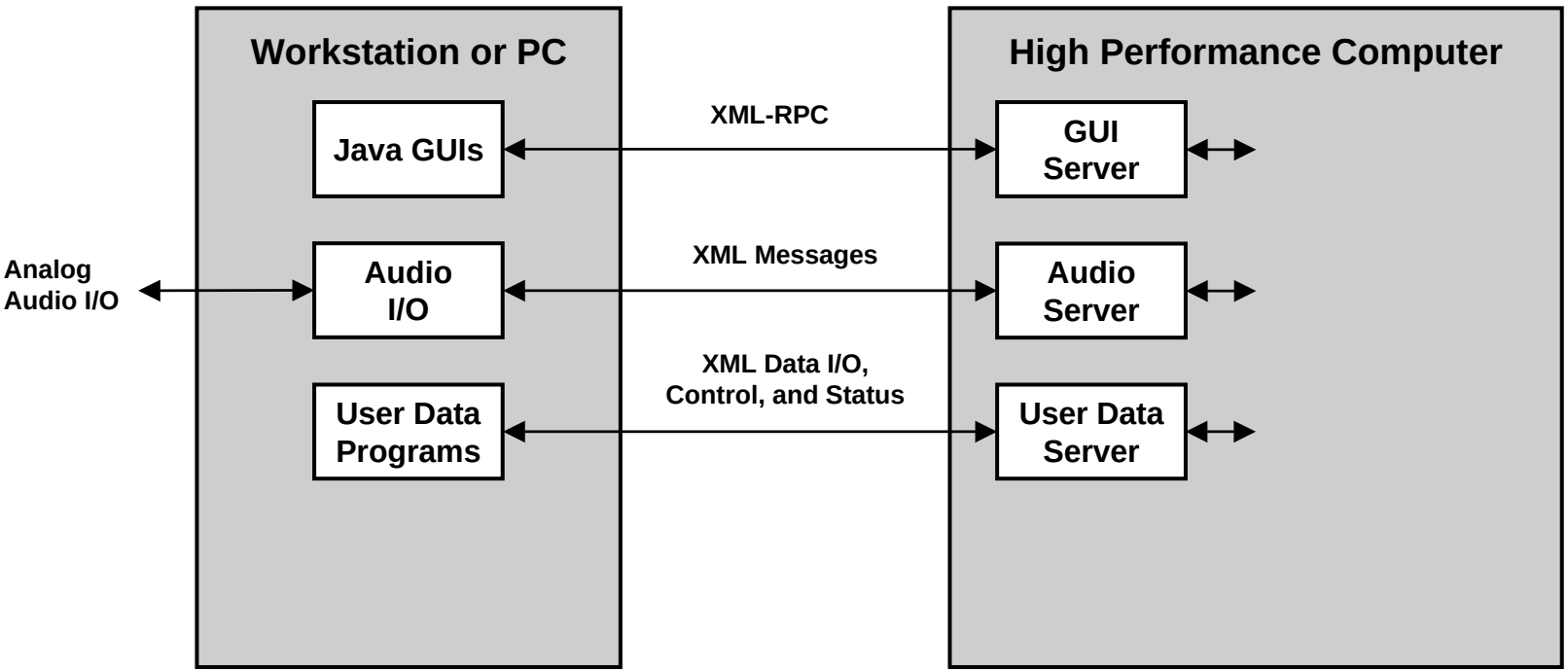
	Alpha	Beta	
Tx Power	√	√	
Tx Antenna Gain	√	√	EBE-03
Spherical Prop Loss	√	√	
Rx Antenna Gain	√	√	EBE-03
Modulation Gain	√	√	
Coding Gain	√	√	
Processing Gain	√	√	
Rx Noise Figure / Sensitivity	√	√	
Polarization Loss	√	√	
Multipath		√	EBE-02 ?
Terrain / Feature Effects		√	EBE-02 ?
Refraction / Ducting		√	EBE-02 ?
Scattering		√	EBE-02 ?
Absorption Loss		√	EBE-02 ?
Environment Noise (Sun, Earth, Moon, Stars, Sun Spots, Lightning, Rain, etc)		√	EBE-02 ?

User Interfaces
Tx or Rx I/O



Note: Java GUIs, Audio I/O, and User Data Programs May Reside on an HPC (Depending on HPC Capabilities and User Needs)

Note: One or More of Each Server Can Run Depending on Loading and User Needs

AN/ARC-164 UHF Radio
Virtual Components

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LOD 2
Java Virtual Components GUI

Real Radio

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AN/ARC-186 VHF Radio
Virtual Components

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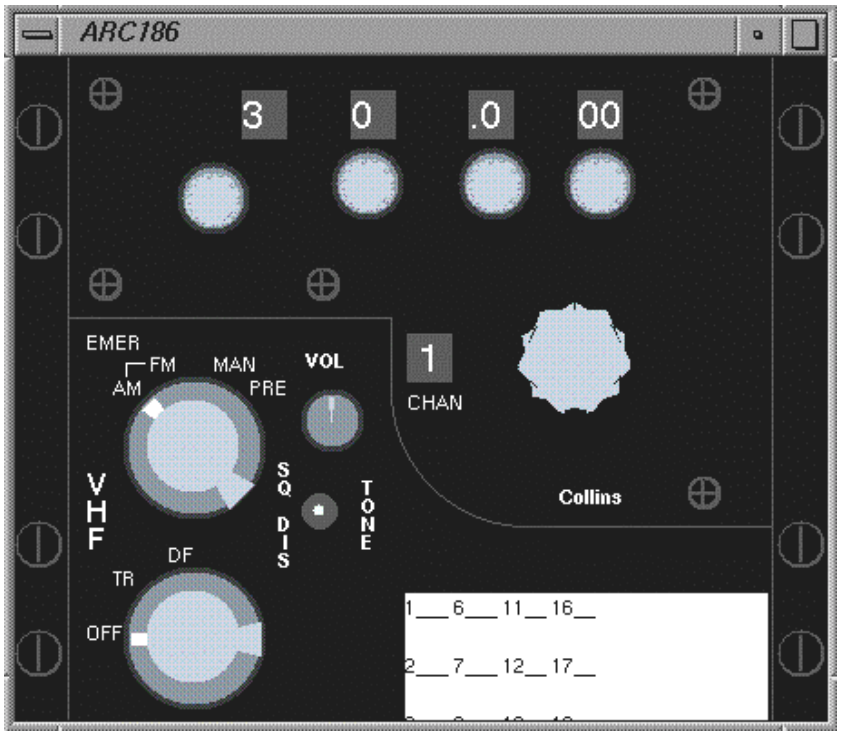

LOD 2
Java Virtual Components GUI

Real Radio

AN/WRN-6 GPS User Set

Java Virtual Components GUI

Real GPS User Set

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GPS Satellite Constellation

Earth View of 29 Satellite Orbits

Orbits from NORAD Two-Line Data

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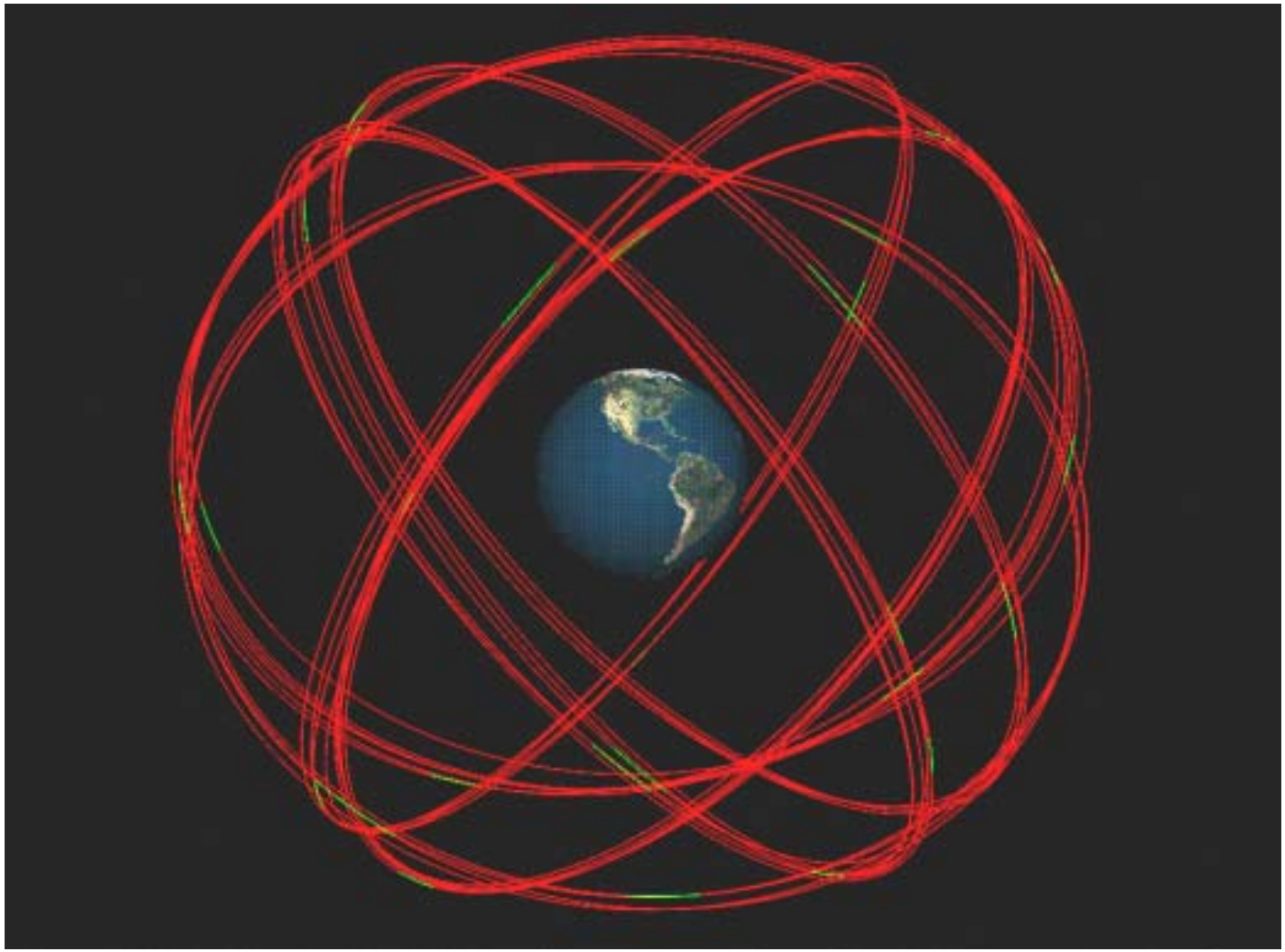

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GPS Satellite Constellation
Entity View

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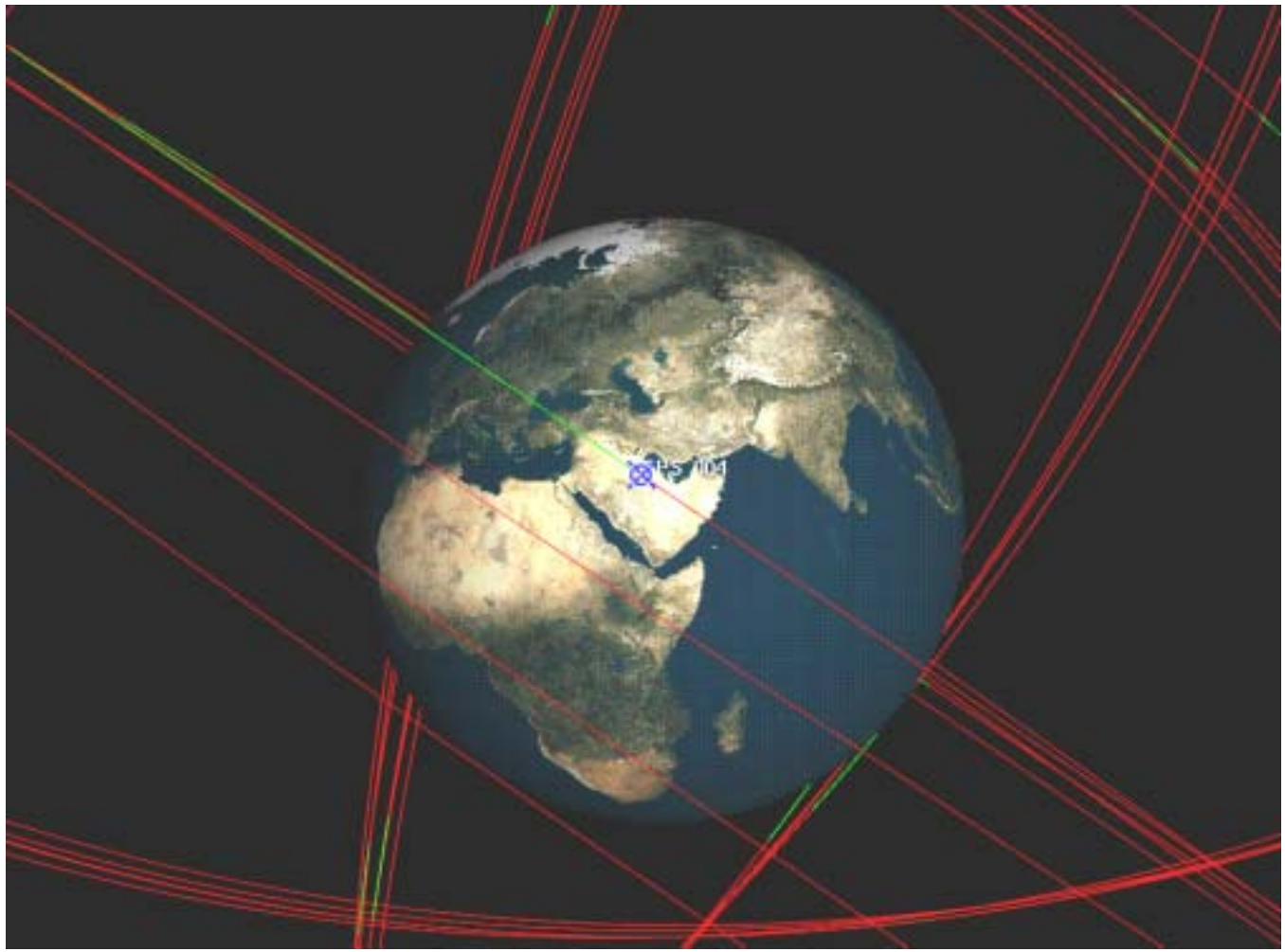

Voice and Noise Filters
Provide Realistic Radio Audio

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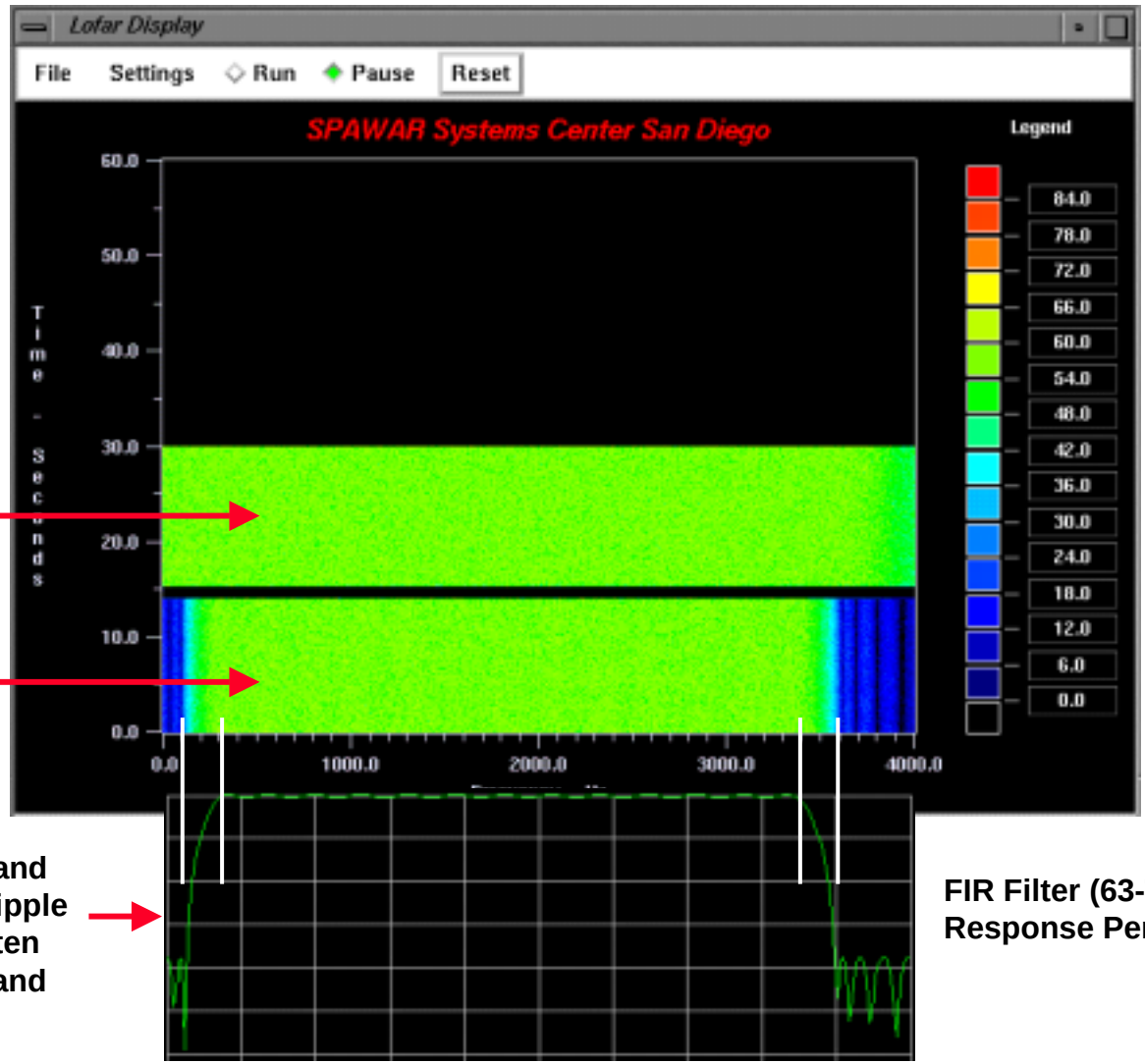

White Gaussian Noise

Filtered Gaussian Noise

300-3400 Hz Pass Band
0.5 dB Pass Band Ripple
40 dB Stop Band Atten
200 Hz Transition Band

FIR Filter (63-Tap) Frequency Response Per MIL-STD-188-113

SAT Scenario