

AFFTC-PA-12495



An Integrated and Collaborative RF Test Infrastructure Presentation

Edward E. Sabat

**AIR FORCE FLIGHT TEST CENTER
EDWARDS AFB, CA**

26 July 2012

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**AIR FORCE FLIGHT TEST CENTER
EDWARDS AIR FORCE BASE, CALIFORNIA
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REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
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1. REPORT DATE (DD-MM-YYYY) 26-07-2012		2. REPORT TYPE Presentation/Briefing		3. DATES COVERED (From - To) July 2012 -	
4. TITLE AND SUBTITLE An Integrated and Collaborative Radio Frequency (RF) Test Infrastructure				5a. CONTRACT NUMBER N/A	
				5b. GRANT NUMBER N/A	
				5c. PROGRAM ELEMENT NUMBER N/A	
6. AUTHOR(S) Edward E. Sabat				5d. PROJECT NUMBER N/A	
				5e. TASK NUMBER N/A	
				5f. WORK UNIT NUMBER N/A	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AND ADDRESS(ES) 412TW/EWG/EWOI 30 Hoglan Avenue BLDG 1030 Edwards AFB, CA 93524				8. PERFORMING ORGANIZATION REPORT NUMBER AFFTC-PA-12494	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A				10. SPONSOR/MONITOR'S ACRONYM(S) N/A	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S) N/A	
12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release A: distribution is unlimited.					
13. SUPPLEMENTARY NOTES CA: Air Force Flight Test Center Edwards AFB CA CC: 012100					
14. ABSTRACT The Benefield Anechoic Facility (BAF) has partnered with various agencies to bring new T&E capabilities forward to ensure we deliver well-tested effective systems to the Warfighter. The DoD, industry and other interested agencies can collaborate and utilize this infrastructure. We have partnered and supported the Army, Navy, Air Force, NASA, partner nations, and other agencies. As part of a Major Range Test Facility Base (MRTFB), the BAF is readily available to the developer and T&E communities. It provides a broad spectrum of RF testing capabilities that include traditional or installed antenna testing, electronic warfare/information operations (EW/IO) system stimulation and response measurement, radar systems test and high intensity radiation field (HIRF) testing among others. But most importantly is the collaborative test capability for the interoperability and compatibility issues of today's Electromagnetic Environment (EME).					
15. SUBJECT TERMS RF Test Capabilities in an RF Anechoic Chamber for EW, IO, RWR, ECM, SIGINT, ELINT, COMINT, Antenna, Interoperability, Compatibility, Systems Testing					
16. SECURITY CLASSIFICATION OF: Unclassified			17. LIMITATION OF ABSTRACT None	18. NUMBER OF PAGES 30	19a. NAME OF RESPONSIBLE PERSON 412 TENG/EN (Tech Pubs)
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified			19b. TELEPHONE NUMBER (include area code) 661-277-8615



Air Force Flight Test Center



War-Winning Capabilities ... On Time, On Cost



An Integrated and Collaborative RF Test Infrastructure

26 July 2012

412TW EWG 772d Test Squadron
Benefield Anechoic Facility (BAF)
Edward Sabat
661-277-8607

412TW.EWG.BAF@edwards.af.mil

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Integrity - Service - Excellence



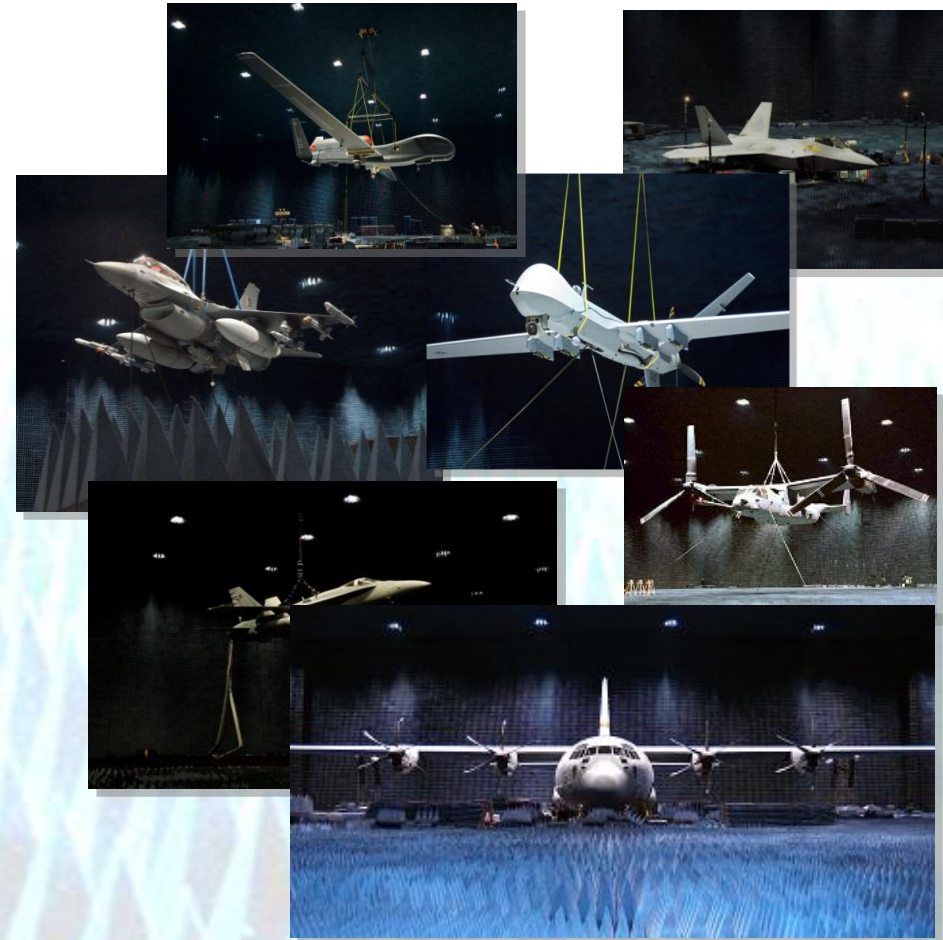
ISTF T & E Challenge



The installed systems test facility (ISTF) must support T&E requirements of diverse RF systems in this EME

- Electronic Warfare (EW) / Information Operations (I/O)
 - Radar Warning Receivers
 - Electronic Support
 - SIGINT/ELINT/COMINT
 - Electronic Attack (EA) (Jammers)
 - On-board and Off-board
- Radar systems
- Antenna systems for all types of avionics and RF systems
- IFFs, Data Links and Satellite Communications

Manned and Unmanned Systems!



Nearly “Anything RF” must be supported



Today's ISTF T&E Requirements



EW/IO Test Requirements that must be satisfied at the installed systems level:

- Present to the system or system-of-system (SoS) a near-real world environment
 - end-to-end-test capability at the mission level and free-space
 - Situational awareness – in the midst of a dense friendly and hostile threat EME
 - System performance (suitability, mission effectiveness, etc...)
 - Threat detection, parametric measurements, identification, processing, response
 - Direction finding (DF), installed antenna patterns and performance
 - Sub-system interoperability/compatibility testing: intra- and intersystem isolation
- ***And now, next generation weapons systems will be more complex and trickier to test...***



Must Mitigate surprises at the OAR or operationally



Future T&E Requirements



Next generation weapons systems will use multiple sensor inputs to detect, correlate, identify, geo-locate and respond to threats

- Complexity, Interoperability, multi-mission, etc...
 - Sensor fusion - SoS with multiple sensor working in concert to provide one solution
 - Networked systems – External data or sensor fusion
 - Smarter and more discriminating intelligent avionics
- New ISTF RF test paradigm with new techniques is needed, for example:
 - Simultaneously and synchronously stimulate multiple (possibly multi-spectral) sensors with higher density free-space than available at the limited ranges
 - More accurate and higher resolution measurements to meet system performance/demands
 - Systems with sophisticated sensor fusion will demand more sophisticated vehicle and avionics systems stimulation and simulation techniques
- All the above tested at the installed system level – ***The T&E Challenge***

Integration of new ISTF test capabilities needed



Capabilities Needed for Today's System



RF T&E infrastructure:

- An ***extraordinarily large anechoic chamber*** facility
- Complete ***RF end-to-end installed systems test***
- Dense, high fidelity ***RF threat simulations*** and verification
- Interactive ***data links and communications***
- ***Electronic countermeasures*** collection, measurement and analysis
- ***Radar target return*** and ***ECM simulation***
- ***Antenna pattern*** measurement
- Inter- and Intra-Systems Electromagnetic (EM) ***Interoperability and Compatibility (EMI/EMC)***
- ***Electromagnetic environmental effects*** (E3) measurements
- ***Global positioning system*** (GPS) signal generation
- Limited sensor fusion

Provide the required environment and data for T & E

The BAF, an ISTF, for example, has brought together and nurtured a robust suite of free-space RF T&E capabilities to meet many of the T&E requirements of systems in a complex environment

- Brings the confidence level beyond that of the M&S and SIL



But...the growth of more complex RF-centric systems and systems-of-systems to respond to evolving and persistent threats is a challenge for ISTFs





The Current BAF Capability...



- **BAF Physical Layout (chamber)**
 - 264 Ft L X 250 Ft W X 70 Ft H
- **Two 40-ton hoists**
- **175-ton 80-ft diameter turntable (One-of-a-kind capability)**
- **Power, Cooling (air and liquid), Hydraulics available**
- **Quiet Zone Isolation**

— 500 MHz*	≥ 72dB
— 1.0 GHz	≥ 84dB
— 2.0 GHz	≥ 96dB
— 3.0-18.0 GHz	≥ 100dB
- * Below 500 MHz special techniques are used to optimize with specific SUT
- **RF Shielding Effectiveness**
 - To/from outside environment ≥ 100dB

“Virtual open-air range” within four walls



Dense and Complex EME Generation



Highly sophisticated – high fidelity and complex Electromagnetic Environment (EME) signal generation - radiated free-space to meet the customer's requirement

- Combat Electromagnetic Environment Simulator (CEESIM) – Threat and Friendly RF EW signals from .1 – 18 GHz
- Joint Communications Simulator (JCS) and others – Communication, Navigation and Identification (CNI) signals and command and control (C²), and data links
- GPS simulation and re-radiation systems
- Cellular (GSM) RF communications
- Radar targets and ECM response
- Radiated Susceptibility High Intensity RF (HIRF) System

Create and see the EME picture before fielding system



Dense and Complex EME Generation



A variety of reprogrammable EME scenarios available from CEESIM, JCS and BAF CNI test assets:

- Realistic threat lay-downs can be planned, scripted and used to stress system designs and pre-fly the system in the BAF
- Correlated to open air ranges or “real world”
- Selectable antenna and scan patterns
- Full variety of modulations (e.g., AM, FM, PM, FSK, PSK)
- Can be complementary to available EME at test ranges
- Land-based, Sea-based, Airborne radars
 - Early warning, acquisition, tracker, launch simulations
 - CW, pulsed ranging, Doppler
- Special or unique assets

A preview to what is expected on range or operationally



Dense and Complex EME Generation



A variety of reprogrammable EME scenarios available from CEESIM, JCS and BAF CNI test assets:

- IFF Modes 1, 2, 3/A, 4, C, Mode S and Mode 5 Interrogators - AIMS Certified (late 2012)
- TACAN - Ground Beacon, Air Interrogators
- Voice Communication
- Voice Files, A/D Input
- Actual Radios
- Data Links - Coherent and scripted content (includes Link 16)
- Background Analog and Digital Signals
- AM, FM, SSB, PN Noise,...
- BPSK, QPSK, ASK, FSK, MSK, QAM,...
- Suitable for background noise and Jammers
- GPS – Simulators or Re-radiation into chamber

A preview to what is expected on range or operationally



CEESIM EME



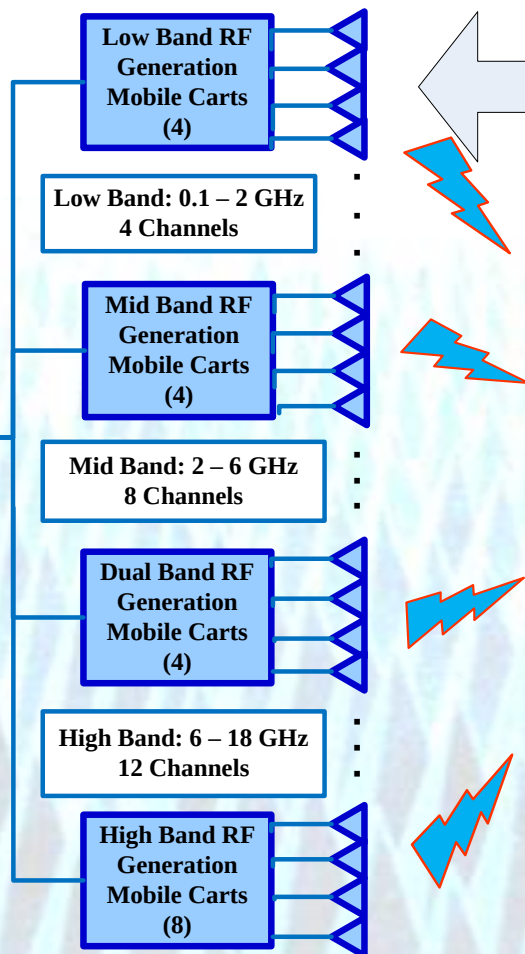
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CEESIM provides:

- Land-based, Sea-based, Airborne radars
- Early warning, acquisition, tracker, launch simulations
- CW, pulsed ranging, Doppler
- Various high fidelity modulations
- Dynamic scenarios of these signals as scripted by the customer requirement



Modulations include AM, FM, PM, FSK, PSK, and others.



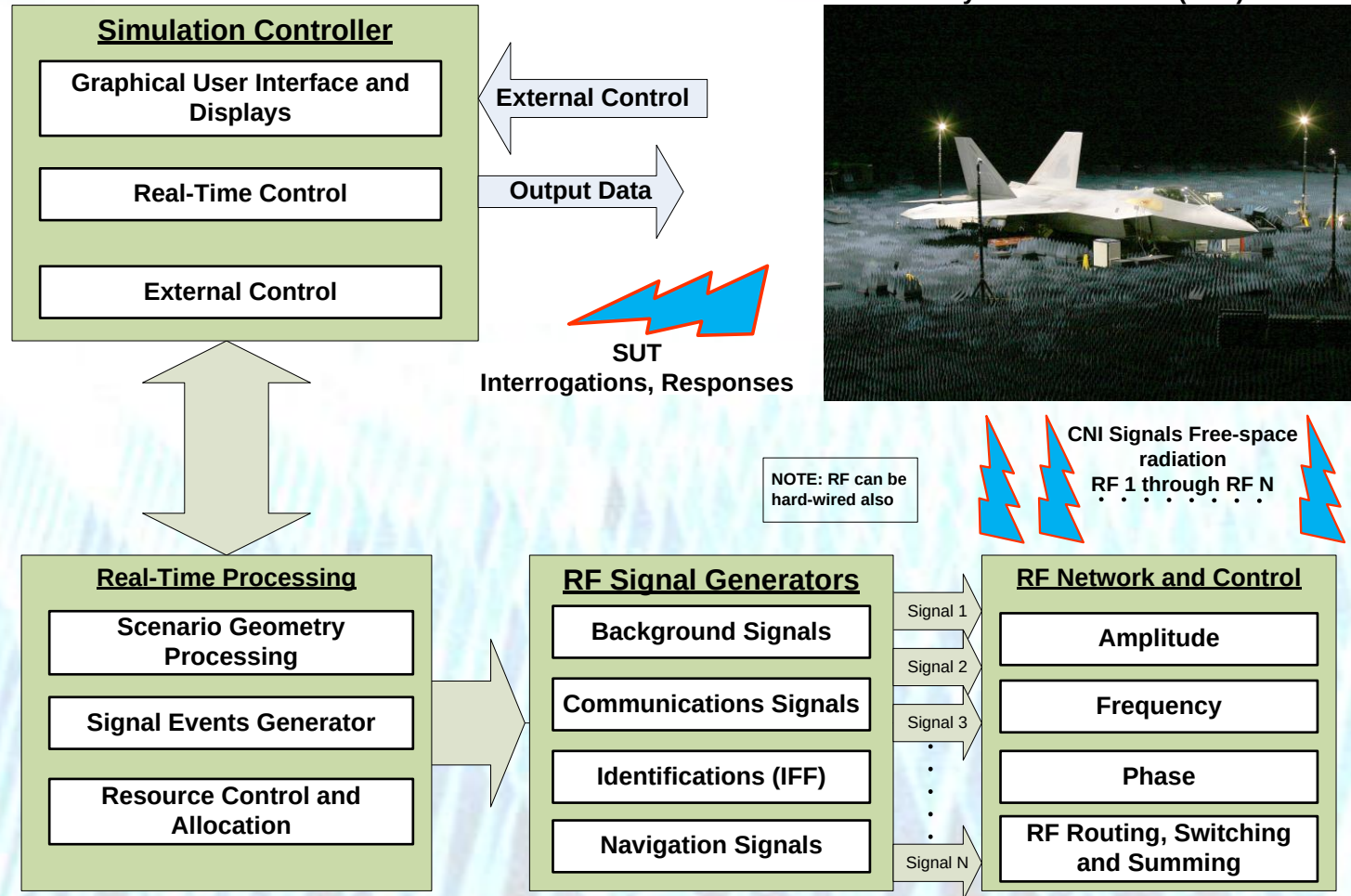
- Antenna Height adjustable from 7 – 35 ft
- Aircraft Position: Up to approx. 50 ft depending on aircraft (or SUT on turntable)
- 20 carts provide up to 24 highly mobile reconfigurable and reprogrammable channels as dedicated or multiplexed channels for higher density scenarios



Free-Space CEESIM RF Scenario Generation



JCS EME



The JCS provides:

- Communications, Navigation and Identification (CNI) signals and command and control (C²)

Complete Avionics Interoperability “Testability”



Radar Testing



Provide radar systems test capabilities and radar target generation

- Radar targets
 - DRFM based responses to SUT radar emissions
 - Provide range, range rate, and Doppler
- Coherent jammer responses
- Returns slaved to radar scanning
- Free space or direct injection
- ***New capabilities integrated***
 - ***Expanding the operating range from X-Band to a new much wider 300 MHz to 40 GHz operating range***
 - ***Radar data capture implemented***

Complete Avionics Interoperability “Testability”

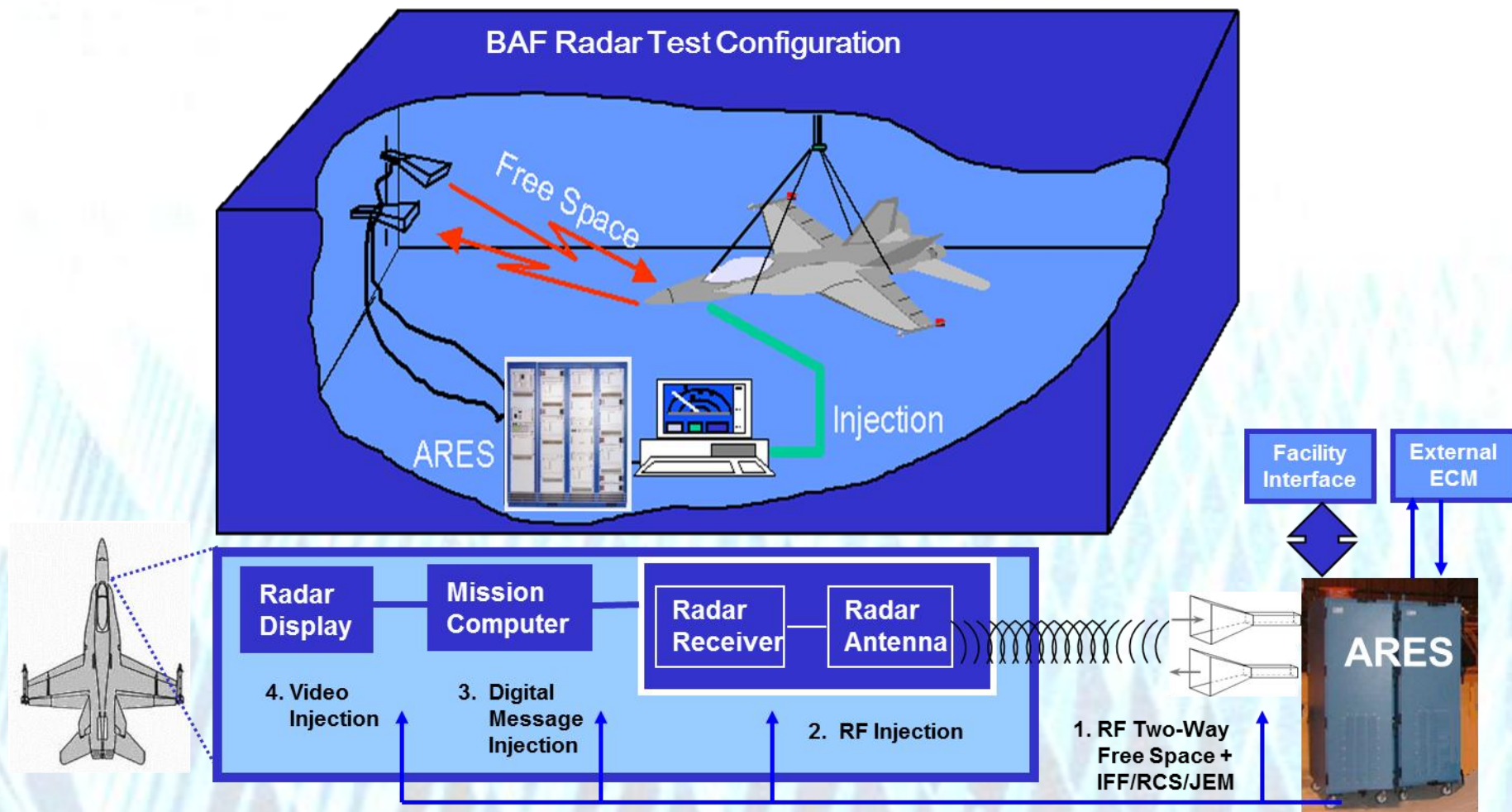


Radar Testing



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Radar Test Scenario



Complete Avionics Interoperability "Testability"



GPS Simulation and Test



Global Positioning System (GPS) GPS integration, tracking and jamming tests must be supported

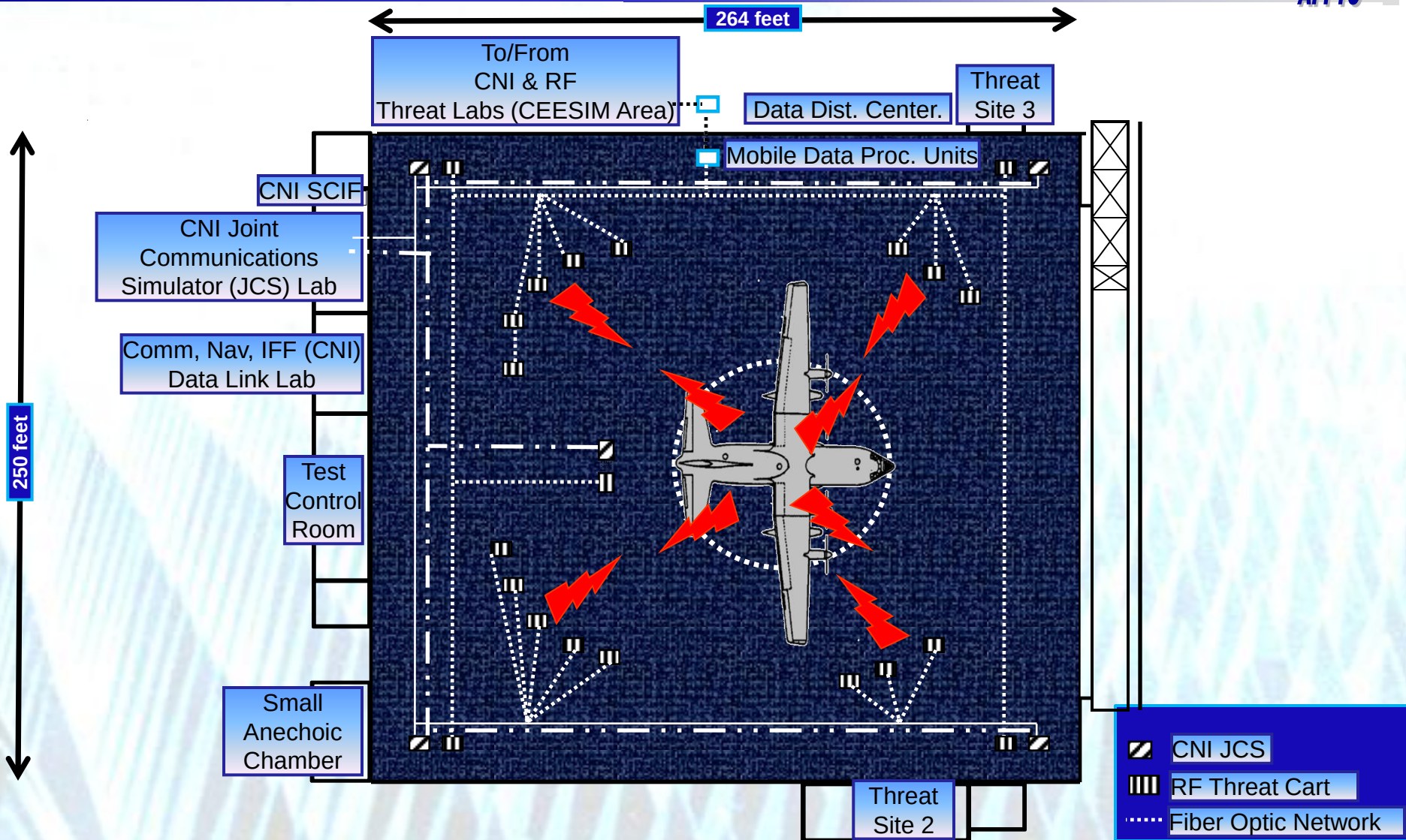
- Internally controlled , no regulatory agency approval required
- GPS Retransmission system
 - Repeats external real world signals - single point
- Interstate GPS Simulator
 - Twenty four (24) satellite signals (single point transmission)
- ***New Advanced Global Navigation Simulator (AGNS) (late 2012)***
 - ***Expands capabilities to meet newer test requirements***
 - *Sixteen RF channels into seven (7) separate L1 and L2 transmit antennas*
 - *Simulates C/A , L2C, P and P(Y) and M codes for Advanced Encryption Code (AEC)*
 - *Modernized NAVSTAR Security Algorithm (MNSA) capable*



GPS - Critical element for today's systems



Typical Test Setup



An Orchestration of a Suite of Complementary Equipment



Distributive Testing and Connectivity



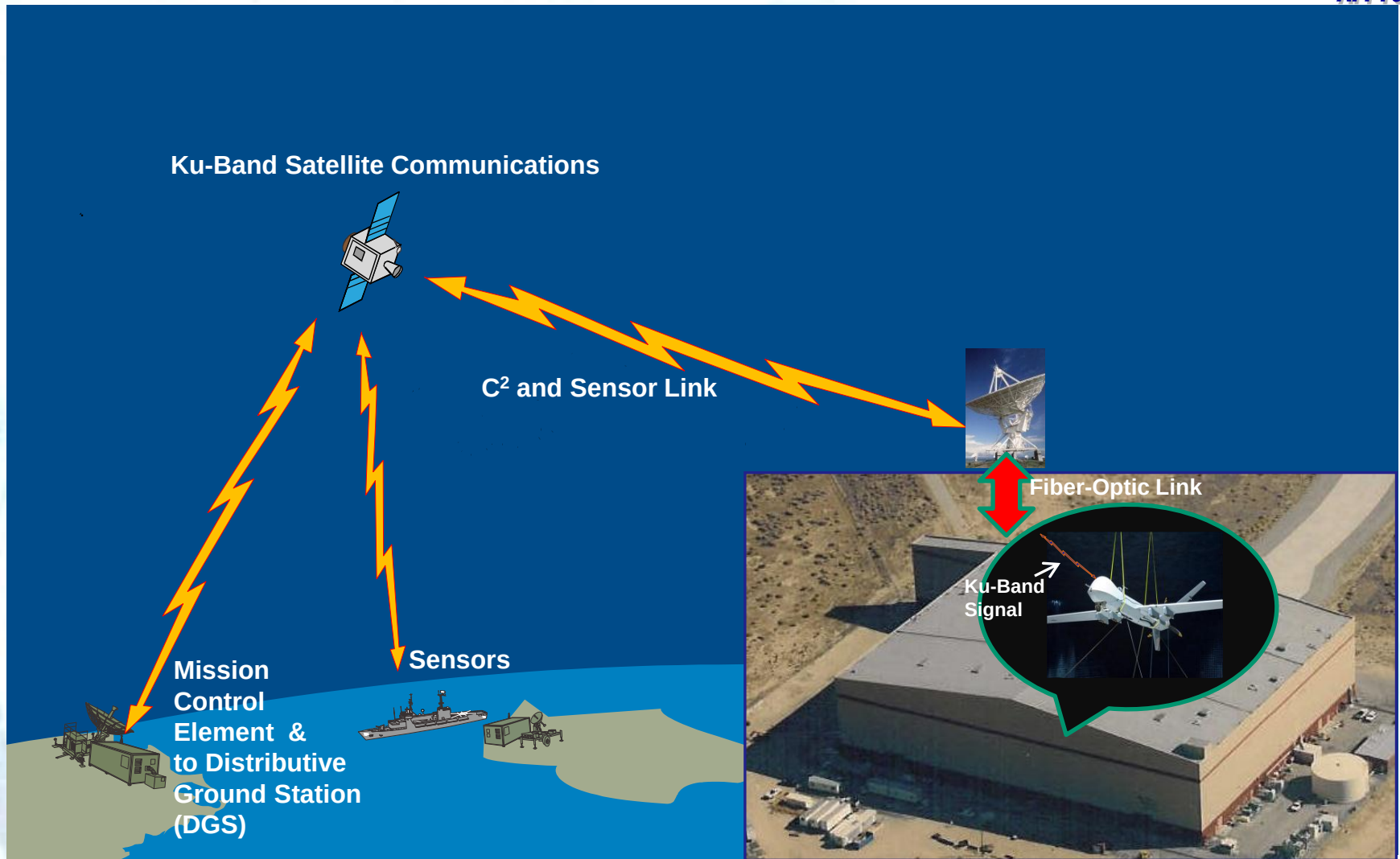
Testing interactively with an external facility or asset may be a significant requirement especially with UASs

- ***New Ku-Band SatCom (July 2012)***
 - ***New capability to meet UAV test requirements***
 - Uplink and downlink connectivity with Ku-Band SatCom-equipped SUT
 - Suitable for any Ku-Band SatCom-equipped aircraft - ***highly desirable for UASs***
- Connectivity with Other test facilities
 - Member facility of the Joint Mission Environment Test Capability (JMETC)
 - DIS, TENA, JREAP architectures
 - DREN, SDREN networks

Integrates remote assets, sensors and mission control elements



Ku-Band SatCom Link



Integrates remote assets, sensors and mission control elements

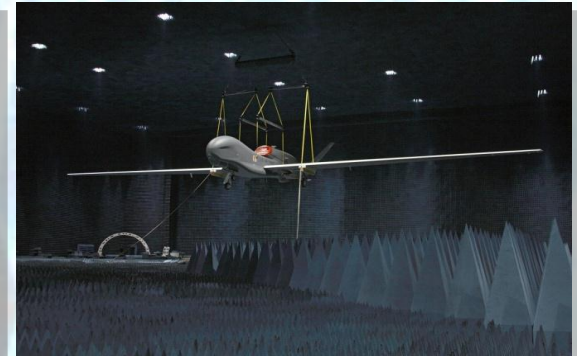


Electromagnetic Environment Effects (E^3)



Today's highly integrated weapons systems must operate in challenging EMEs and meet demanding integration and interoperability requirements

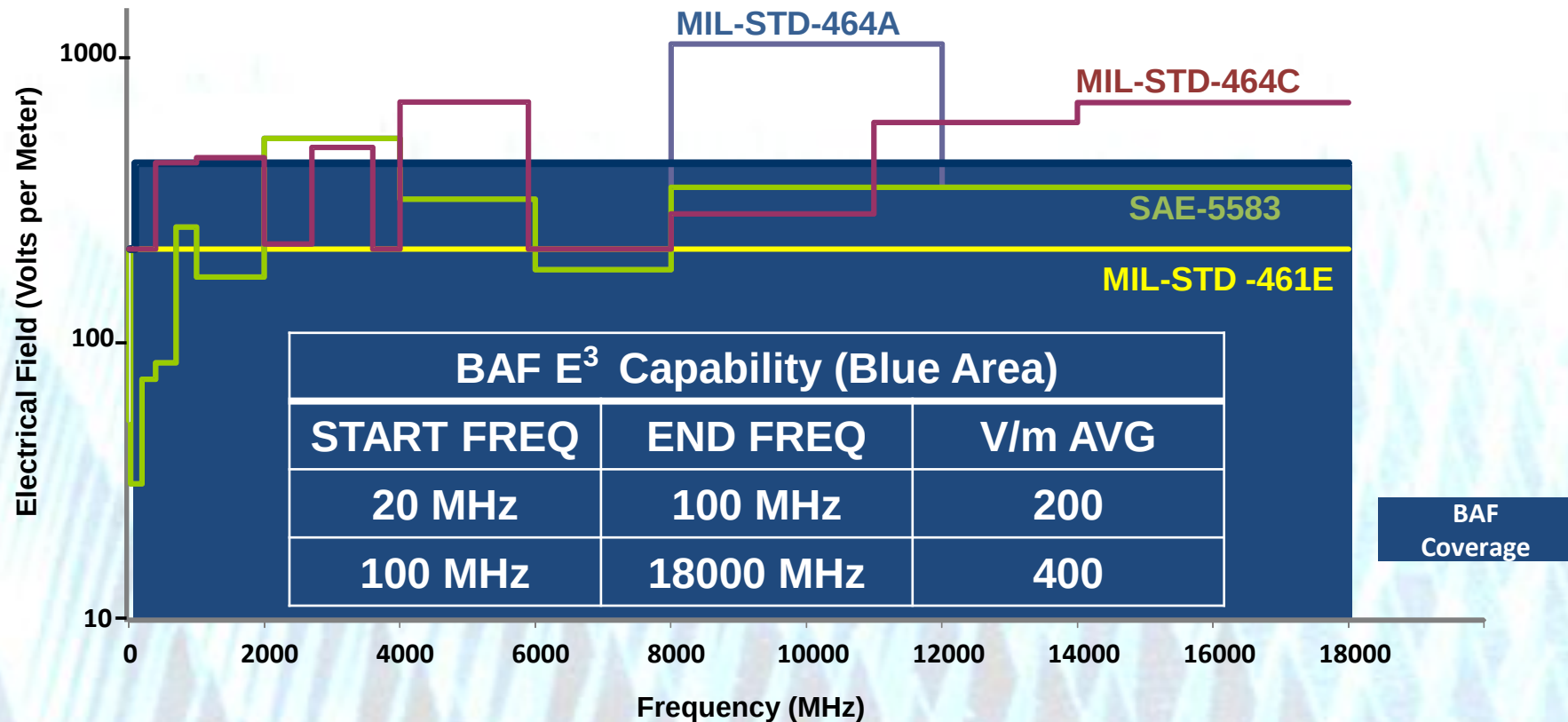
- ***New Enhanced E^3 capability – implementation for HIRF (Sept 2012)***
 - Radiated Emissions (IAW MIL-STD 461)
 - Radiated Susceptibility (IAW MIL-STD 464)
- Inter- and Intra-system Interoperability
 - Antenna isolation (Source-Victim)
 - Systems to systems effects (EMI/EMC)



Ensure suitability, mission effectiveness and safety of flight



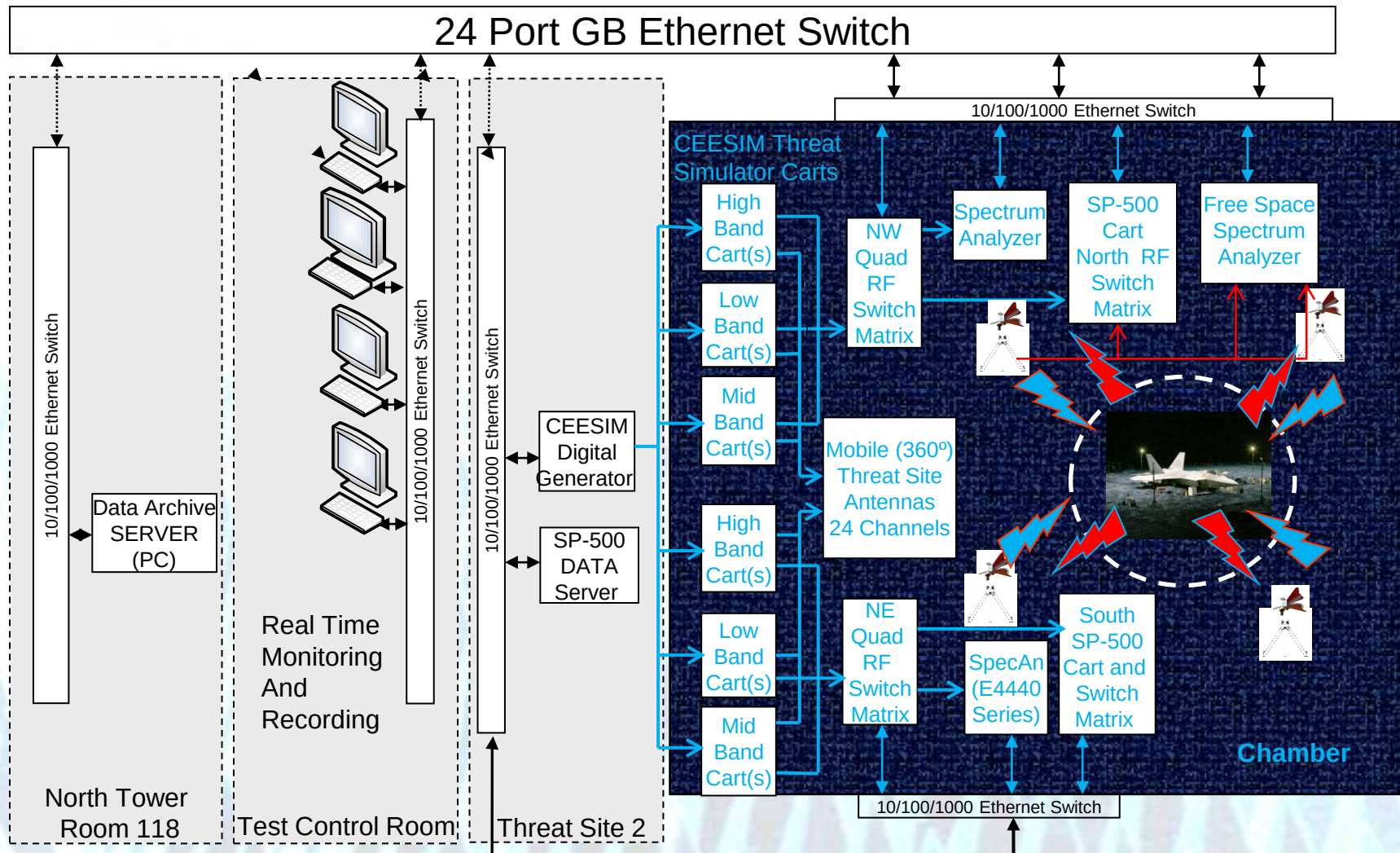
Electromagnetic Environment Effects (E³)



Comparison among Typical Standards



RF Monitoring Capabilities



Sample of RF Monitoring Configuration for Chamber

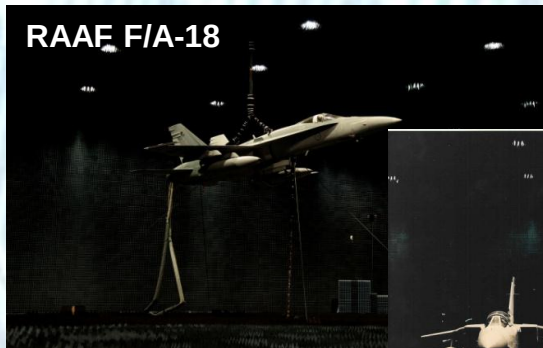


Snapshot of Prior Tests



A history of quite a diverse customer base and test requirements for such platforms as,

- USAF: F-22, CV-22, C-130, C-17, RQ-4, MQ-1/9, F-16, F-15, B-1B, B-52, U2
- US Navy: F/A-18 Hornet/Super Hornet, F-14, Harrier, Lear RCS
- US Army: Apache, MH-47 (Chinook)
- NASA: F-15, F-16, MISTIE, X-43, X-51
- FMS: RAAF F/A-18, Israeli F-15, Pakistani F-16
- Foreign: UK Typhoon and Tornado, EuroHawk
- Commercial: Boeing RAAF Wedgetail, F-15 Singapore, BMW



RAAF F/A-18



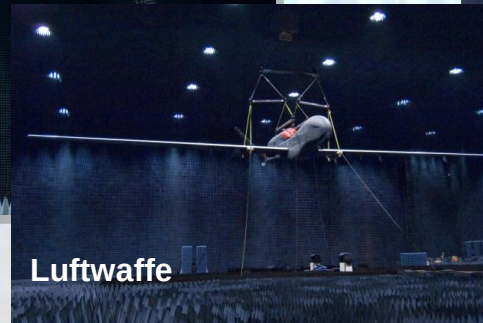
NASA - USAF



US Army



RAF



Luftwaffe



US Navy



Collaboration



Recognize the need for and existence of various test facilities with specific capabilities (Major Range Test Facility Bases (MRTFBs))

- Collaboration and support of the right test at the right facility in a cost-effective manner is imperative
- Must meet with potential customer
 - Understand and evaluate requirements - What facility is the best facility for the test?
 - Point customer to other test facilities if it is in the customer's best interest or...
 - Team with other facilities to best meet customer and technical needs
- The BAF actively participates in joint T&E activities and capability development
 - Presently need to address the multi-sensor fusion and density test capability
- MRTFBs should accommodate DoD, FMS and commercial customers





Summary



A highly capable and robust T&E ISTF infrastructure to support the DoD, industry and our allies in the test of today's highly integrated weapons systems for today's EME is essential

- Developmental Test (DT) and Operational Test (OT)
 - Installed systems integration verification and baseline
 - Realistic integrated, dense, controllable and secure test environment
 - Validated, correlated, and coordinated signals - correlation to open-air range assets
- Secure test environment for sensitive signals (SAP, SCI, War Modes) to support DT and OT Battle-Space environment or when restricted by regulatory agencies
- ISTF takes systems test confidence to levels above that of M&S or a SIL
- ***A need for the stimulation and control of the newer smarter systems is still needed for the next generation systems***
 - ***Collaboration among developers (government and industry) and testers needed to integrate test capabilities into key ISTF facilities***

Major T & E capabilities available, always adapting to systems



Contact Information



412TW EWG 772d Test Squadron Benefield Anechoic Facility

30 Hoglan Ave
Edwards AFB, CA 93524

Ed Sabat
661-277-8607

412TW.EWG.BAF@edwards.af.mil
edward.sabat@edwards.af.mil



Fly it in an ISTF before you take it outside and play!

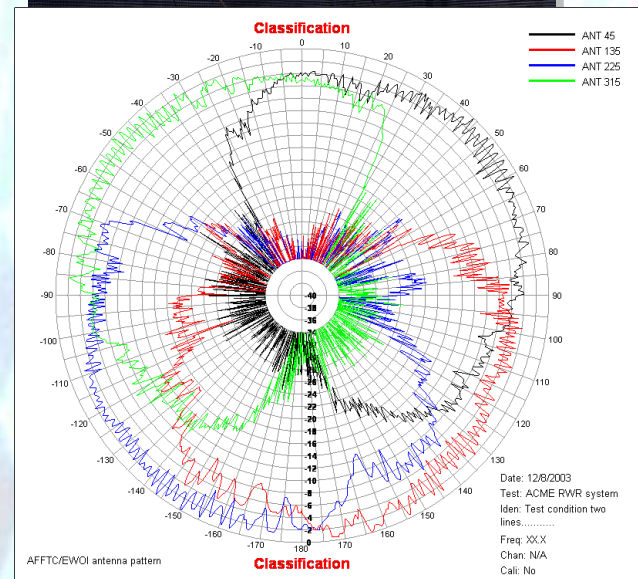


Antenna Pattern Measurements



Measurement resources must provide stand-alone and installed patterns of passive and active antennas

- Frequency range 0.1 to 18 GHz
 - Time gating techniques are applied for lower frequencies ($\leq .5$ GHz) or for other special requirements
- Rapid automated data collection
 - Multiple frequencies, angles, and polarizations can be collected within a single sweep
- High rate of data collection in an installed system environment
 - Useful for the population of system performance and mission planning models



K	L	M	N	O
Corrected	Corrected	Corrected	Corrected	Corrected
AMP C01	AMP C02	AMP C03	AMP C04	
-44.4927	-48.3327	-45.0506	-57.3906	
-45.7235	-47.7035	-46.23	-42.71	
-45.2543	-46.8843	-42.7094	-43.1784	
-41.5252	-43.7552	-45.6888	-56.0088	
-42.446	-49.706	-42.4162	-39.3262	
-38.0869	-43.2569	-38.4076	-42.7476	
-36.1677	-44.7377	-45.107	-39.547	
-39.9086	-38.2786	-35.6663	-36.8663	
-37.5404	-41.8704	-44.3357	-40.7657	
-40.1102	-42.4702	-37.9051	-37.4051	
-39.7411	-41.5411	-41.9345	-42.9445	
-35.1619	-46.3019	-43.0438	-42.2038	
-33.2628	-38.2028	-41.4032	-48.8732	
-34.1036	-37.6036	-41.2326	-45.8026	
-35.0344	-37.5544	-46.6319	-47.8819	
-36.7453	-36.6953	-36.1113	-37.2013	
-36.8861	-37.6761	-39.6707	-39.2007	
-38.857	-37.687	-35.34	-35.47	
-39.9478	-44.1278	-36.2994	-40.6794	
-34.5306	-36.8496	-36.3287	-37.6387	
-37.6295	-36.7095	-34.9581	-37.4081	
-39.9203	-36.1603	-41.1374	-42.5274	
-40.6511	-36.8411	-33.4468	-37.5768	
-38.352	-36.802	-44.0861	-44.3961	
-38.3128	-37.6628	-40.1955	-43.6955	
-42.9536	-41.0136	-42.4148	-39.3348	