Annex A – ELECTRONIC WARFARE T&E FACILITY DESCRIPTIONS

A.1 INTRODUCTION

This annex provides descriptions of known EW and related T&E facilities in NATO Nations. Whilst it does not fully describe every resource that a project may wish to utilise, it represents a valuable resource for understanding the range of facilities available to meet the goals of a structured test process.

A.2 FACILITIES LISTING

This annex was compiled by the authors with the help of the national representatives on SCI FT3, and it is the most current available at the point of issue. All information has been provided by the respective facilities. It is non-exhaustive; for new and/or upgraded facilities information, check with your national representative. To assure the latest information on any facility or resource, engage with the Point of Contact given at the end of each listing.

NATION	FACILITY/RESOURCE NAME	ORGANISATION/LOCATION	PRIMARY DESIGNATION
GBR	Electromagnetic Modelling Group	BAE Systems, Lancashire	M&S
ITA	Antenna Design and Testing Group	Alenia Aeronautica S.p.A., Turin	M&S
DEU	Cassidian Computational Electromagnetics	Cassidian, Manching	M&S
USA	Integration Facility for Avionic Systems Testing	USAF, Edwards AFB, California	SIL
USA	Portable Seeker/Sensor/Signature Evaluation Facility	USAF, Eglin AFB, Florida	SIL
USA	ECSEL	USN, Point Mugu, California	HITL
USA	Benefield Anechoic Facility (BAF)	USAF, Edwards AFB, California	ISTF
GBR	EW Test Facility (EWTF)	BAE Systems, Lancashire	ISTF
USA	Air Combat T&E Facility (ACETEF)	USN, Patuxent River, Maryland	ISTF
GBR	Electromagnetic Test Capability	BAE Systems, Lancashire	ISTF
ITA	Anechoic Shielded Chamber	Alenia Aeronautica S.p.A., Turin	ISTF
ITA	Electromagnetic Open Area Test Sites	Alenia Aeronautica S.p.A., Turin	ISTF
USA	J-PRIMES	USAF, Eglin AFB, Florida	ISTF
DEU	Cassidian EME Test Facility	Cassidian, Manching	ISTF
USA	Electronic Combat Range (ECR)	USN, China Lake South Range, California	OAR
SWE	Vidsel EW Test Range	Swedish Defence Materiel Administration, Vidsel	OAR
USA	Center for Countermeasures (CCM)	US DoD, White Sands Missile Range, New Mexico	OAR
GBR	Joint EW Core Staff	NATO, RNAS Yeovilton	OAR
USA	T&E Support for Aircraft Survivability	USAF, Eglin AFB, Florida	OAR
GBR	Trials/Test Support Group	ESL Defence Systems, Hampshire	OAR

In addition to the above, some Nations also maintain a catalogue of T&E capabilities, some of which are applicable to EW. Examples include:

NATION	CATALOGUE TITLE/REFERENCE	CONTACT
GBR	UK Test and Evaluation Catalogue D/Wpns/TEST/03/02/07/CatalogueV6 dated July 2011	DESWpnsTEST-TECC2@mod.uk

A.3 MODELLING AND SIMULATION RESOURCES

A.3.1 Electromagnetic Modelling Group

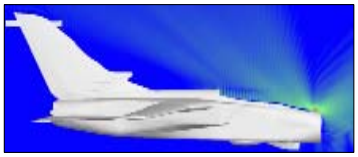
TEST RESOURCE CATEGORY

Primary: M&S / Other: (Not Applicable).

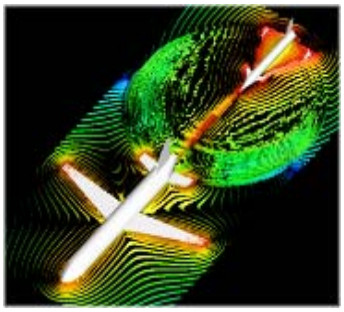
LOCATION

BAE Systems, Military Air Solutions, Warton, Lancashire, UK.

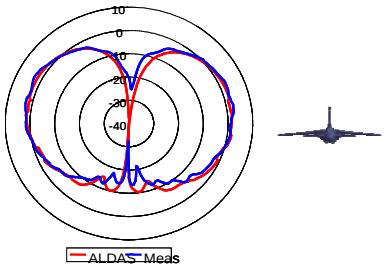
NARRATIVE DESCRIPTION



The Group has access to a suite of Computational Electromagnetic Modelling (CEM) codes covering all the major frequency and time domain modelling techniques (see Capability Summary). These are used on a 512 core parallel processing supercomputer capable of 1.5 TFLOPS with 1.5 TBytes of core memory, which is dedicated to electromagnetic modelling.



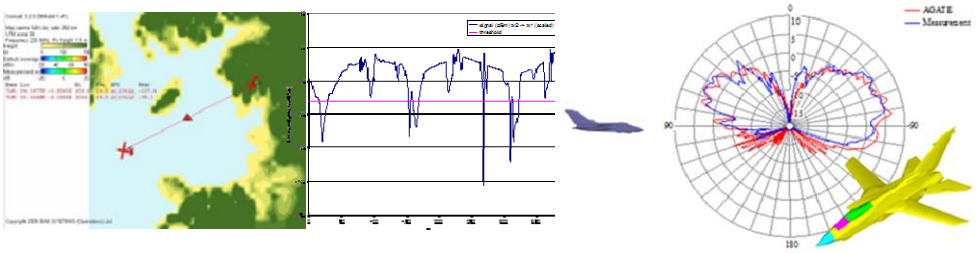
The Group can import design data (structure, cabling and pipework, including material properties), directly from Computer-Aided Design (CAD) systems and, with a minimum of intervention, automatically create suitably gridded geometries. Thus 1 billion cell models are regularly created and analysed. For microwave frequencies the ray tracing codes are available.



This computational facility is utilised by the Group's experienced, specialist engineers to provide solutions to a wide range of electromagnetic problems including installed antenna performance, in terms of polar diagrams, antenna coupling and RF systems performance. The latter uses the installed antenna modelling output in modelling tools which enable assessment of communications link performance in different scenarios and platform, RF interoperability analysis.

The capability is also used to simulate the interaction of lightning, Electro-Static Discharge (ESD), Electromagnetic Pulse (EMP) and High Intensity Radiated Fields (HIRF) with systems internal and external to any platform, including cable currents and equipment electromagnetic environment.

It is used throughout the design and support life-cycle to establish concepts, carry out design optimisation and risk reduction through to design verification and supporting qualification of 'first of type' and upgrades during in-service support.



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CAPABILITY SUMMARY

Electromagnetic Software Tools

Most of the applications software has been developed and maintained within BAE Systems to meet general requirements across a broad range of products and design solutions. A key aspect of these facilities is the link to CAD generated geometry accommodating all major CAD systems.

All major electromagnetic modelling codes/methods are represented including:

- Transmission Line Method (TLM)
- Finite Difference Time Domain (FDTD)
- Boundary Element (BE)
- General and Uniform Theory of Diffraction (GTD/UTD)
- Fast Multi-Pole Method (FMM)
- Hybrid finite element / finite difference
- Antenna communications link modelling software
- Antenna coverage modelling software

Applications

The engineers are experienced in applying our modelling tools to address a wide range of electromagnetic threats, interactions and issues seen on vehicles, systems and other structures including:

- Installed antenna interoperability (coupling)
- RF systems performance, including the propagation path
- Un-installed and installed antenna coverage (polar diagrams)
- Antenna/system range
- Lightning strike (direct and indirect effects)
- Electromagnetic Pulse (EMP)
- Electrostatic Discharge (ESD)
- Electromagnetic Compatibility (EMC) and High Intensity Radiated Field (HIRF) threats

Our engineers have wide experience using electromagnetic modelling on many practical products (now certified and in service) in all parts of the product life-cycle, including concept, design, certification and through-life support.

Computational Electromagnetics High Performance Computing

Large parallel super-computers are required for the grand-challenge scale of processing required for whole vehicle, high fidelity simulations. The facilities are dedicated to electromagnetic computer analyses as these tend to involve long run-times which are incompatible with multi-user shared resource environments. The most powerful facility currently available is:

HP/Quadrics Cluster:

- 64 compute nodes each containing dual AMD Athlon 64 -bit quad core processors giving a total of 512 cores
- 1.5 TByte core memory
- Quadrics QSNet II high performance interconnect

POINT OF CONTACT

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A.3.2 Antenna Design and Testing Group

TEST RESOURCE CATEGORY

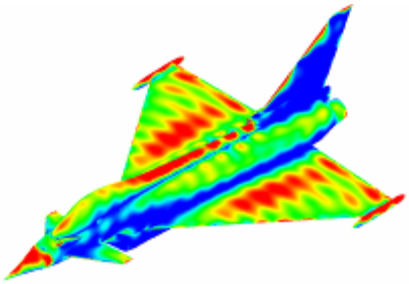
Primary: M&S / Other: N/A.

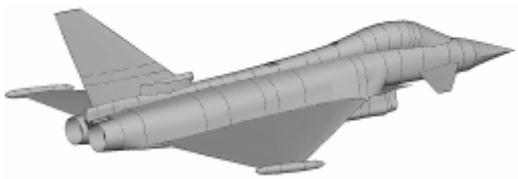
LOCATION

Alenia, E3 -Avionic Systems and Laboratories, Turin, ITALY.

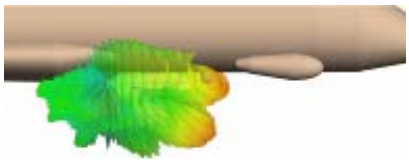
NARRATIVE DESCRIPTION

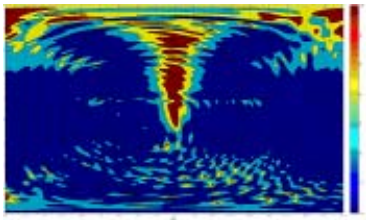
The Group is involved in the analysis of the antenna performance installed on Alenia platform, using the commercial state-of-art computational tools based on the principal frequency and time domain techniques to solve Maxwell's Equations. Electromagnetic problems are solved with a dedicated network of nine 64-bit workstations, with 640 GBytes of core memory that can manage multi-processor computations.

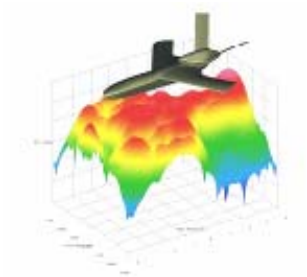


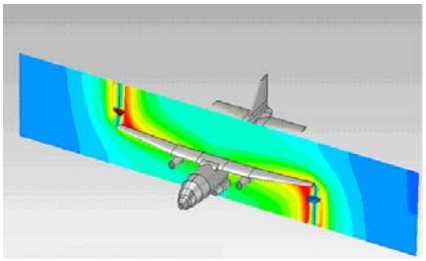


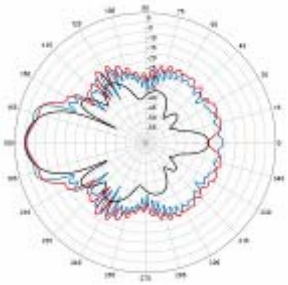
The tools are able to import directly the Computer-Aided Design (CAD) files, including cable routing and material proprieties, that the engineer experts will correct in an accurate and reliable model, from an Electromagnetic (EM) point of view. The main activity of the group deals with aircraft EM design: antenna siting aiming to ensure properly positioning of antennas on platform fuselage and to minimize/control unwanted EM interference between on-board transmitters and receivers, taking into account all aircraft mechanical constraints. Antenna to Antenna Coupling values, Antenna Radiation Patterns and Antenna Near Field Iso-Surface values can be numerically calculated, visualized and exported for further post-processing analysis. During and after design phase, confidence and accuracy of computational results can be assessed by performing only a small set of representative measurements, using computational predictions as a starting point for informed and efficient measurement preparation and planning. The HW computational capability allows the performance of parallel processing for overcoming all of the most demanding electromagnetic problems, such as evaluation of Radar Cross-Section at air vehicle level.











CAPABILITY SUMMARY

Electromagnetic Software Tools:

Almost all of the state-of-art EM numerical tools are available for Antenna Design and Testing group. Electromagnetic techniques/codes available are reported in the following:

- Method of Moment (MoM)
- Multi-Level Fast Multiple Method (MLFMM)
- Finite Element Method (FEM)
- Boundary Element Method (BEM)
- Finite Differential Time Domain (FDTD)
- Approximate EM formulations such as Physical Optical (PO), Geometrical Optical (GO), Uniform Theory of Diffraction (UTD), Physical Theory of Diffraction (PTD), Large Element PO (LEPO)
- Hybrid formulations such as MoM/PO, MoM/GO, MoM/UTD, MoM/PTD, MLFMM/LEPO, FEM/MLFMM, MoM/MLFMM
- Shooting Bouncing Ray (SBR) and incremental length diffraction coefficient algorithms for radar cross-section analysis

Applications

Antenna engineering expert use the HW and SW facilities to solve a wide variety of electromagnetic problems

- Antenna design
- Antenna placement (coverage)
- Antenna-to-antenna coupling
- RF interoperability analysis
- Lightning strike (direct and indirect effects)
- Bidirectional cable field co-simulation
- Electromagnetic Compatibility (EMC) and High Intensity Radiated Field (HIRF)

The available computational tools and the know-how engineers acquired in several years allow to adequately solve complex electromagnetic problems: in the last years the major activity has been the antenna placement. Now, group is able to predict global electromagnetic aircraft environment.

Computational Electromagnetic Computing

Dedicated network of 64-bit workstations are used to solve electromagnetic problems, guaranteeing good accuracy and confidence between calculated results and measured value. The most powerful facility currently available is:

HP/Dell Network:

- Eight 64-bit workstations, dual-quad core Intell, with a total of 64 processor and 512 GByte of core memory
- One 64-bit workstation, dual-quad core Intell, with 128 GByte of core memory

POINT OF CONTACT

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A.3.3 Cassidian Computational ElectroMagnetics

TEST RESOURCE CATEGORY

Primary: CEM.

LOCATION

CASSIDIAN, Manching, GERMANY.

NARRATIVE DESCRIPTION

Cassidian has a custom 3D numerical simulation capability, for the full spectrum of electromagnetic applications, including antenna design and integration, for military, space and civil applications.

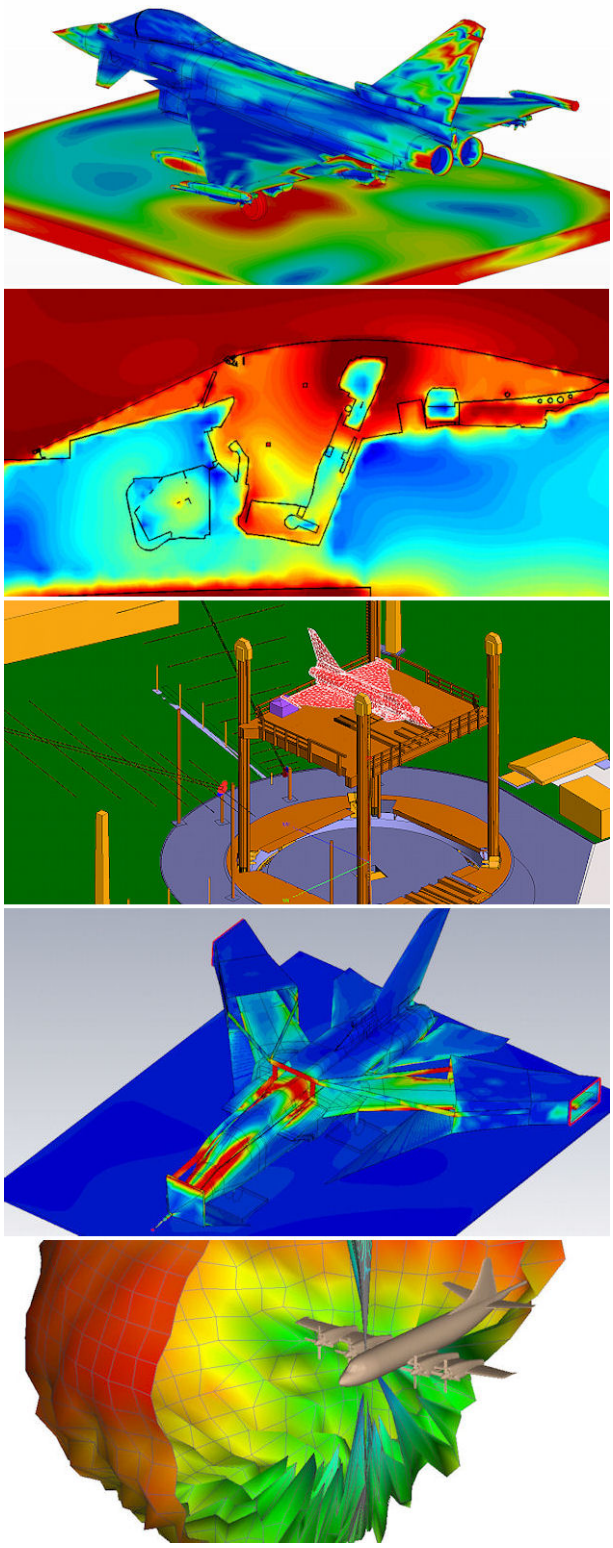
In support of this, a highly professional EM numerical tool set and high performance simulation computer hardware are available.

Computational EM Analysis is useful when measurements are not possible or practical with respect to time or costs, or when EMC tests (e.g., RE, CE, RS, CS) have FAILED and no solution was found, or when extremely high requirements exist with respect to Radiated or Conducted Emissions, as well as when EMC confidence is required to show compliance before prototyping.

CEM is also useful when Antenna performance needs be optimised for maximum operating distances, or for assessing whether commercially available antennas are suitable for specific applications, or when the antenna measuring equipment and/or expertise is not locally available.

Cassidian has substantial experience in 3D numerical simulations on advanced fighter A/C and other systems, in the prediction of very complex electromagnetic coupling behaviour.

Programs already supported include the Eurofighter TYPHOON, the Panavia TORNADO, the C-160 TRANSALL, and the P-3C ORION CUP.



CAPABILITY SUMMARY

Application Examples

- Radiated emissions from electronic equipment
- Shielding effectiveness
- Lightning analysis for direct and indirect effects
- Lightning zoning of all kind of vehicles
- Determination of unknown electromagnetic resonances based on current distribution analysis, with all kinds of materials, e.g., metal, carbon, composites, plastics.
- Verification of protection measures against all kinds of EMC related threats, such as conducted susceptibility (CS-XX), radiated susceptibility (RS-XX), LEMP and NEMP
- Antenna design, e.g., thin-film conformal annular slot antennas
- Antenna modelling of the radiation characteristics where measurements are not practical
- Access to non-destructive, 3D X-ray scanning
- Human safety: Definition of safety zones for high-power transmitters
- Disguised antennas: Adaptation of antenna designs to hide them in structural parts
- Performance simulation in specific environments, e.g., behind a radome
- Co-site interference analysis, decoupling and spectrum management
- Link predictions based on 3D wave propagation analysis

Electromagnetic Software Tools

- FEKO – Method of moments, MLFMM, FEM, GO, PO, UTD
- CST Microwave Studio – Finite Integration Technique and other EM solvers
- ASERIS BE/FD – Boundary Element Method with GUI, Finite Difference Time Domain with GUI, Mesher
- Wireless Insite – Uniform Theory of Diffraction + empirical models for wave propagation analysis
- Hypermesh – CAD Meshing
- E3-Expert – Interference analysis tool

High Performance Computational Electromagnetics Computing Facilities

- 2-Node High-Performance Cluster (4 x Xeon Hexa-Core CPUs, 24 Cores @ 2.7 GHz, 384 GB RAM, ≈ 400 GFLOPS)
- 4-Node High Performance Cluster (8 x Xeon Quad-Core CPUs, 32 Cores @ 3 GHz, 284 GB RAM, ≈ 600 GFLOPS)
- 4-Node Cluster (4 x Xeon Dual-Core CPUs,16 Cores @ 3 GHz, 64 GB RAM)

POINT OF CONTACT

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A.4 SYSTEM INTEGRATION LABORATORY

A.4.1 Integration Facility for Avionic Systems Testing

TEST RESOURCE CATEGORY

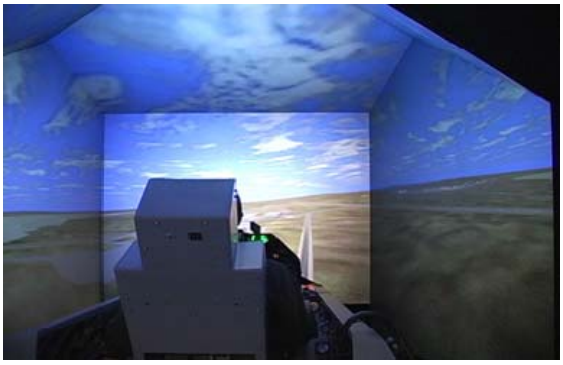
Primary: SIL / Other: M&S, HITL.

LOCATION

Edwards Air Force Base, California, USA.

NARRATIVE DESCRIPTION

The System Integration Laboratory (SIL) is a flyable F-16 cockpit and simulation dome with significant Hardware-In-The-Loop (HITL) environment and open-air capability. This spread bench test environment provides Test Pilots and Engineers with a safe and effective environment for system evaluation and training. This unique capability also supports integration of new development items such as targeting pods, tactical data links, weapons, sensors and other items. Available spectral environments include Radio Frequency (RF), Electro-Optic (EO), Infrared (IR), and Electromagnetic Support Measures (ESM). The SIL supports Developmental Test (DT), Operational Test (OT) and other special test activities as determined by its customers.



Manned Flight Simulation (MFS) provides pilots and engineers capabilities to train and assess weapon systems during initial development, or in sustainment and modernization activities. Aircraft representative cockpits and displays are mechanized with aircraft Operational Flight Profile (OFP) software, driven by functional simulations to provide flight dynamics and/or avionics stimulation. High resolution and 360 degree horizontal / 240-degree vertical field of regard out-the-cockpit video provide a realistic environment to exercise weapon system capabilities. MFS provides the USAF and its contractors with a safe and effective environment for familiarization, develop flight profiles and test event timing, develop detailed test card procedures, and develop and debug aircraft systems, mature flight test procedures and timing, and assess weapon system performance. MFS supports Developmental Test (DT), Operational Test (OT) and other special test activities as determined by its customers.

CAPABILITY SUMMARY

SIL Capabilities	SIL Configurations

• Human factor interface
• Flight safety evaluations (i.e., ground collision avoidance)
• Mission development and rehearsal
• Full avionics system test
  • Avionics suite integration/testing
  • Line replaceable unit level testing
  • Anomaly investigation
  • Communications, navigation, ID
• Sensor integration
• EW blue/red man-in-the-Loop stations
• Weapons simulation, integration, and testing
• Digital bus and video data retrieval
• Crewmember/engineer familiarization/training
• Distributed linking (situational awareness)
• Tactical data links: Link-16, SADL, IDM
	• F-16 Cockpits (complete avionics hardware suite supporting Blocks 30, 40, 50, M3 and M4 architectures)
	• APG-68 Radar operators console
	• Link-16 landline or open-air
	Environmental Simulations
	• Fog
	• Time-of-day
	• Pressure/temperature altitude variations
	• Flat or spherical earth coordinate system

Mission Threat Environment The SIL can be linked with the Digital Integrated Air Defence (DIADs) simulation to provide an enemy air defence threat environment. The DIADs includes air interceptors, radar posts, GCI positions, filter centers and command post simulations with real operator in the loop capability. Other threat capability features include: • Graphically displayed air-to-air and air-to-ground targets and threats • Synthetic target sensor models to support Targeting Pod (TGP) and Fire Control Radar (FCR) • Synthetic RF target generation for stimulating actual radar systems • Combat Electromagnetic Environment Simulator (CEESIM) RF threat generation	
MFS Capabilities **Flight Sciences** • Envelope expansion • Flight control failure • Flight dynamics • Human factors with integration studies • Emergency procedures • Sensitivity analysis • Mission rehearsal	**Environment Conditions M&S** • Ownship winds • Fog/clouds • Rain/snow • Lighting with communication degradation • Time-of-day with sun/star positions • Sea states • Pressure/temperature altitude variations • Flat or spherical earth coordinate system

POINT OF CONTACT

412th EW Group
30 Hoglan Avenue
Edwards AFB, CA 93524-8210, USA
Tel: 661-275-7615 (DSN 525)

A.4.2 Portable Seeker/Sensor/Signature Evaluation Facility

TEST RESOURCE CATEGORY

Primary: SIL / Other: N/A.

LOCATION

Eglin Air Force Base, Florida, USA.

NARRATIVE DESCRIPTION

The Portable Seeker/Sensor/Signature Evaluation Facility (PSSSEF) provides several different flexible airborne and ground instrumentation platforms that can host an interchangeable mix of instrumentation that allows full characterization of surface and airborne targets. Hi-fidelity target signatures are critical for seeker/sensor development, guided weapons evaluation via simulated engagements, and live fire target validation. Measured target signatures are used to develop and validate digital signature models for hi-fidelity simulated weapons engagements. For example, IR and EO models can be provided in SPIRITS, CHAMP, and Real-Time CHAMP (RTC). The PSSSEF can collect and provide data in a wide variety of test scenarios including: simultaneous multi-spectral measurements of ground, sea, and airborne targets; measurement and characterization of aircraft flares and decoys; measurement of transmission, attenuation and backscatter of aerosols, obscurants and chaff; radar cross-section measurements of sub- or full-scale vehicles; characterization of radar absorbing material performance; background clutter measurements; antenna gain pattern measurement; and the effects of battlefield smoke, dust and chaff on C3I systems. PSSSEF provides signature measurements across the full operational spectrum including infrared, ultraviolet, visible, RF/millimeter wave, acoustic, seismic, and magnetic and can perform a full complement of measurements providing temporal, spatial, spectral, SAR/ISAR, LADAR, and calibration data. Several airborne carriage platforms are available including an F-15 for sub-sonic and supersonic carriage, a UH-1N Helicopter, and a Beech 18 aircraft. Ground facilities include the 300 ft Santa Rosa Island tower for land, sea, and air measurements, the 300 ft Seeker Test and Evaluation Facility (STEF) tower, and various test vans and trailers.

CAPABILITY SUMMARY

 300 ft Open-Air Simulation Tower on Santa Rosa Island	 *Seeker Test and Evaluation Facility*
IR/UV/Visible Measurements • Temporal, spatial, spectral • 1.5 – 3 microns • 3 – 5 microns • 8 – 12 microns • 263 – 281 nm (UV) • Visible	***RF and Millimeter Wave (MMW)*** • Ground, tower, and airborne-based systems • 10, 35, 95 GHz
Key IR/UV/Visible Instruments • STIRRS – Staring IR Radiometric System • ABSTIRRS – Airborne Staring IR Radiometric System • CIGARS – Calibrated IR Ground/Airborne Radiometric System • ASIMS Airborne Spectral IR Measurement System • TELOPS – 320 x 256 Ft Imaging Spectrometer (3 – 5 microns) • FLIR Systems SC6000 Imaging Radiometers (640 x 480 long wave, mid wave, short wave, and near IR)	***Key RF and MMW Instrumentation*** • AMIRS (Advanced MMW Imaging Radar System): 7, 10, 17, 35, and 95 GHz • MROCS-2 – (MMW Obscurant Characterization Sys): 10, 35, and 95 GHz • Lynx: Ku-Band Synthetic Aperture Radar (SAR) on B-18 • MERAJS (MMW Emitters, Radars, and Jamming Sys) • MMS (MMW Materials Measurement Sys) • DEWSIM (Directed Energy Weapons Simulator) consisting of various high-power microwave sources

POINT OF CONTACT

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A.5 HARDWARE-IN-THE-LOOP

A.5.1 ECSEL

TEST RESOURCE CATEGORY

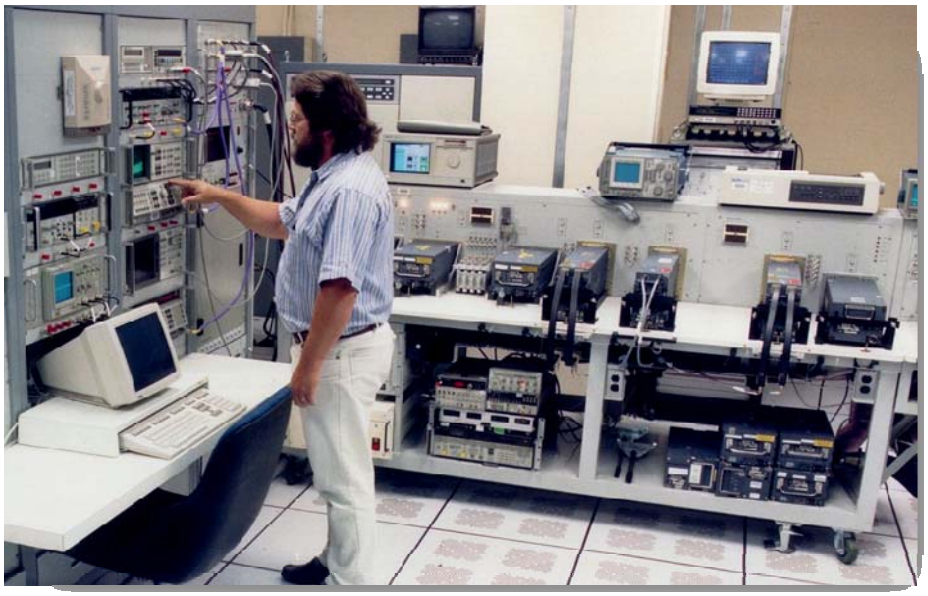
Primary: Hardware-In-The-Loop Ground Facility.

LOCATION

Naval Air Warfare Center Weapons Division, Pt. Mugu, California, USA.

NARRATIVE DESCRIPTION

Occupying 10,000 square feet of high security Radio Frequency (RF) shielded space, the ECSEL houses threat simulation, instrumentation, and computer resources required to perform developmental test and evaluation of new EW systems and techniques, integration of EW components and sub-systems, and testing of new software revisions for EW systems presently deployed. Commonality between simulations on the ECR range and in the ECSEL make the ECSEL an efficient facility for troubleshooting EW system problems revealed during flight test.



The test approach used in the laboratory is one that incorporates actual EW system hardware interacting with the threat simulator. The threat simulators operate in real time at actual frequencies and receiver power levels. Open-loop RF environment simulators provide high signal densities which model emitter characteristics of threat systems such as airborne, land-based, and shipboard radars, as well as active command guidance signals for missile systems. Closed-loop simulators provide high fidelity replication of complete radar directed weapons systems such that the effectiveness of active jamming responses can be measured. Closed-loop simulations also include missile hardware simulation for semi-active threat systems. A scenario control computer, with associated aircraft cockpit and flight controls, provides the means to coordinate the simulators and incorporate realistic flight dynamics in the test process. This allows the EW system to be “flown” in laboratory scenarios that represent the electromagnetic environment encountered in actual combat or scenarios that will stress the EW system to its limits.

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A.6 INSTALLED SYSTEMS TEST FACILITIES

A.6.1 Benefield Anechoic Facility (BAF)

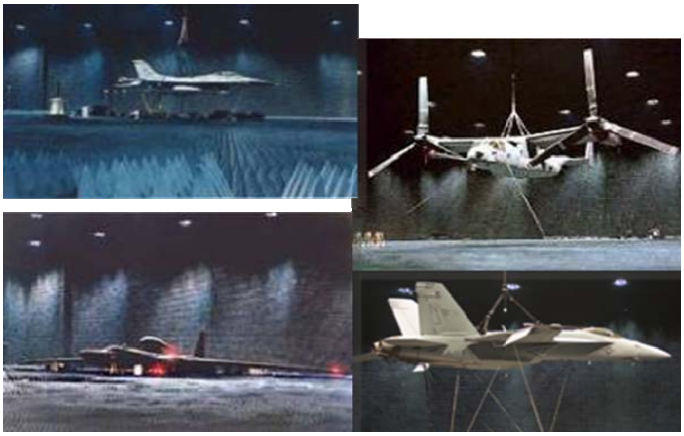
TEST RESOURCE CATEGORY

Primary: ISTF / Other: MF, SIL, HITL.

LOCATION

Edwards Air Force Base, California, USA.

NARRATIVE DESCRIPTION



The Benefield Anechoic Facility (BAF) provides the installed system ground Test and Evaluation (T&E) element of the EW T&E process. This facility offers customers cost effective comprehensive ground test capabilities to thoroughly evaluate current and future complex, highly integrated, software-intensive avionics suites and EW systems installed on host aerospace platforms as well as ground-based platforms.

The primary purpose of the BAF is to test integrated avionics systems in a secure, controlled, and repeatable electromagnetically quiet environment using state-of-the-art simulation and stimulators that closely duplicate real combat mission environments. The test team also has collected, modeled, and generated high fidelity threat waveforms that are representative of the Open Air Range (OAR). It is also an ideal installed system test facility to evaluate performance and investigate anomalies associated with ground and airborne EW and avionics systems and tactical missiles and their host platforms.

Capabilities include simulation of airborne and ground-based threat radar, Communication, Navigation, Identification (CNI) simulation; radar target generator, GPS and GPS jamming; electromagnetic interference and compatibility testing and antenna pattern measurement and system of systems testing in a secure, dense environment.

The size of the large chamber also allows for far field RF radiation, thereby making most simulations much more accurate. The BAF is ideal for interoperability testing between multiple aircraft placed in the chamber simultaneously. The BAF supports Network Centric Operations testing with its ability to provide an electromagnetically dense threat environment coordinated with high bandwidth Link 16 test scenarios. The facility includes monitoring and instrumentation, two man-rated hoists, a turntable, interconnecting networks, a test control room, presentation rooms, and office space, and a small anechoic chamber for component tests. These laboratories can work autonomously or collectively to provide varying levels of test and analysis capabilities. All the laboratories are connected via a fiber optic network for communication, instrumentation, and data collection, monitoring and recording.

The Radio Frequency (RF) signal acquisition system provides independent measurement of all intentionally radiated RF emissions seen during testing. The signal acquisition system can provide both a

near real-time analysis and a record of time sensitive, event driven, emitter activities and responses. These records include high resolution power, precision pulse-width, and accurate pulse interval measurements. The system is versatile enough to capture free space threat emissions or provide input ports to perform direct injections for source calibration or troubleshooting.

CAPABILITY SUMMARY

Benefield Anechoic Facility • Anechoic chamber and several shielded test laboratories • Offices, conference rooms • Secure facilities (tailored to program requirements)	**Chamber Dimensions** • Shield: 264 ft long x 250 ft wide x 70 ft high • Flight line door: 196 ft wide x 66 ft high • Three man doors

Support Services
• 175 ton 80 ft diameter turntable can rotate the system under test +/- 180 degrees at a 0.1 – 0.6 deg/sec.
• Two 40-ton hoists
• Aircraft electrical power:
  • 400 Hz, 115 VDC, 3Ø (General)
  • 270 VDC (Supports F-22 and JSF)
  • Support multiple aircraft simultaneously
• Instrumentation power: 28 VDC, etc.
• Cooling air: 6,600 CFM @ 10 PSI @ 30°F
• Hydraulic system: 4,000 PSI MIL-H-5606 and 83282
• Two Polyalphaolefin (PAO) Systems
RF Transmission and Reception
• Both free space radiation and direct injection capabilities are available
• Free space radiation has 20 RF generation carts arranged in the chamber to provide the desired sector and angle of arrival density
• Travelling Wave Tube (TWT) and solid-state amplifier configurations available
• Programmable, with control over all simulation and hardware functions. Scenario simulations are fully dynamic, providing for static or moving threats
• Direct injection capability provides various combinations of signal density and injection ports
• RF signal reception configuration:
  • All RF generation carts output monitored continuously
  • Chamber environment continuously monitored for SUT emissions and spurious signals
  • ECM response measurement
  • Threat simulator output verification
  • Chamber RF environment characterization
  • Integration of jammer pod response waveforms with a radar target return
	Shielding
	• Isolation: 100 dB 0.5 – 18 GHz
	• Quiet zone: 15 – 55’ height x 209’ x 180’
	  • -72 dB @ -0.5 GHz
	  • -84 dB @ 1 GHz
	  • -96 dB @ 2 GHz
	  • -100 dB @ 3 – 18 GHz
	• Anechoic frequency range: 0.4 – 18 GHz
	Instrumentation
	• Free space: 24-channel CEESIM MkN
	• Surface and airborne radars > 1000 simultaneous emitters
	• Dense threat environment (> 2 M pulses/sec)
	• High Fidelity Intrapulse Modulation (HFIM)
	• Provides pulse shaping capability every 15 ns
	• 21 channels with fast tuning synthesizers
	• 3 channels with slow tuning synthesizers
	• 2 amplifier configurations TWTA and SSA
	• Fiber optic connectivity to 20 carts which can be placed anywhere on the chamber floor
	• Frequency band 100 MHz – 18 GHz
	• Direct inject: 6 channels (amp and phase) CEESIM MkN
	• Designed for multiple port and channels configuration
	• Fast tuning synthesizers or digitally tuned oscillators
	• Frequency band 100 MHz – 18 GHz
	• Portable: 5 channels CEESIM MkN
	• Fast tuning synthesizers or digitally tuned oscillators
	• Frequency band 100 MHz – 18 GHz
	• Joint communication simulator system
	• Scenario based, complex RF signal generation system
	• Capable of creating a realistic, simulated RF environment comprised of thousands of CNI emitters/data links on thousands of platforms

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A.6.2 EW Test Facility (EWTF)

TEST RESOURCE CATEGORY

Primary: ISTF / Other: MF, SIL, HITL.

LOCATION

BAE SYSTEMS, Military Air Solutions, Warton, Lancashire, UK.

NARRATIVE DESCRIPTION

The EWTF complex comprises an aircraft-sized, RF- and laser-shielded anechoic chamber, shielded rooms, and an EW Sub-System Test Laboratory, all TEMPEST grade. It is co-located with the Division's Electromagnetic Engineering Department, who run the EWTF and other related M&S, MF, HTIL and SIL capabilities. Together, this whole-domain Electromagnetics Capability provides a flexible and reliable whole-life design and T&E service to military and other platforms. With EW T&E resources including state-of-the-art Combat Electromagnetic Environment Simulator (CEESIM) and Signal Measurement System (SMS)[1] for RF threat simulation and ECM response and analysis, other standard laboratory test equipment, and all necessary support infrastructure, the EWTF supports:

Free space chamber '*electronic battlefield*' testing of un-installed EW equipment, sub-systems, systems, and of installed EW systems on combat-sized aircraft and other platforms of similar size, in total electromagnetically secure conditions.

Direct signal injection and measurement testing of EW systems in a SIL/HITL environment.

The figure shows a selection of aircraft tested in the EWTF. The platform is immersed in a virtual battlefield for EW testing. Whilst primarily a 'drive in, drive out' EW ISTF, it is also used as an EW MF for installed antenna performance measurements, high intensity radiated field EMI/EMC testing, and full threat lightning testing. These are usually whole aircraft tests in the chamber, and the EWTF is simultaneously an EW MF and an Electromagnetics ISTF. The EWTF houses Computational Electromagnetics super-computers, the department's primary M&S capability. 1 – 18 GHz RCS measurements are also conducted in the chamber. These are described elsewhere in Annex A.

Selection of Aircraft Tested in EWTF
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[1] CEESIM and SMS are Northrop Grumman Amherst Systems products.

CAPABILITY SUMMARY

EWTF Complex • Anechoic chamber and sub-system test laboratory • Offices, conference rooms, visiting team room • Secure vault (up to top secret; multi-Nation partitioned) • Peritrack access from EWTF to nearest runway	**Anechoic Chamber Dimensions** • Shield: 30 m long x 23.8 m wide x 13.5 m high • RAM-tip to RAM-tip: 29.1 m x 22.9 m x 12.5 m • Main door: 16 m wide x 12.5 m high • Two human-sized access doors, one double door

Shielding
• Shielding > 100 dB from 10 kHz to 40 GHz
• TEMPEST grade, fully welded shield
• Quiet zone 18.2 m diameter, 9.5 m high
• Two quiet zone locations: centre and 4.7 m offset toward main door
• Quiet zone performance (up to 40 GHz):
  • Monostatic: -90 dB
  • Bistatic: -80 dB
• Laser/electro-optic/IR/UV testing: Class 4 laser-tight, double safety door interlocks
	Support Services
	• 70 tonne static capability
	• 30 tonne crane and 30 tonne turntable: independent and synchronised operation, 0.1 – 1.0°s-1 rotation rate
	• Sub-turntable laboratory and services room
	• Power: single/3∅ UK, 115/200 V 400 Hz 3∅ aircraft
	• Hydraulics: Max 280 bar, 180 litres/minute
	• Compressed air: > 10 bar, 22 m^3/minute
	• Static and mobile CCTV and video recording
	• Multi-zone fire detection and suppression:
	  • Smoke/heat, thermal cameras (RAM temperature)
	  • Water deluge: 1 ton/second for 3 minutes

RF Transmission and Reception
• Six threat site multi-antenna stacks:
  • Four corners, at floor level; one at centre of wall opposite door; one at top of that wall
  • Steerable stacks, with laser pointer
  • Multiple transmit/receive antennas per stack
• Threat simulation configurations:
  • Basic: 21 TWTAs (microwave/millimetre wave)
  • Variety of other amplifiers, up to 1 – 18 GHz 1 kW CW and 9 kW pulsed (4%)
• Basic RF signal reception configuration:
  • ECM response measurement
  • Threat simulator output verification
  • Chamber RF environment characterisation
	Instrumentation
	• 11 channel CEESIM MkN:
	  • Microwave/millimetre wave channels
	  • 2 high speed synthesiser channels, 6 others available to be fitted as needed by test
	  • 256 emitters, 256 platforms, simultaneous at RF
	  • Modes: stand-alone, close-coupled and fully controlled by external control computer
	• SMS / Time synchronisation system:
	  • Wide-band, digitized IFM receiver
	  • Dual-channel, 80 MHz instantaneous bandwidth
	  • Extensive real-time/post-processing capability
	  • Event-driven signal capture
	• EW measurement system:
	  • Microwave/millimetre wave, 10 MHz bandwidth
	  • 25 MHz sampling ADC, 90 minute recording
	• Other: Microwave laboratory analysers, data

Further information: Pywell, M. and Midgley-Davies, M. Improved Test Capabilities for Cost-effective Performance Evaluation of Airborne Electronic Warfare Systems, J.RAeS, V.114, No.1158, September 2010.

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A.6.3 Air Combat Environment Test and Evaluation Facility (ACETEF)

TEST RESOURCE CATEGORY

Primary: ISTF.

Location

Naval Air Warfare Center Aircraft Division (NAWCAD), Patuxent River, Maryland, USA.

NARRATIVE DESCRIPTION

The Integrated Battlespace Simulation and Test (IBST) Department, within NAVAIR, owns and operates the Air Combat Environment Test and Evaluation Facility (ACETEF). This fully integrated ground test facility supports Test and Evaluation (T&E) of highly integrated aircraft, weapon systems, and ground vehicles in a secure, controlled and electromagnetically quiet environment. ACETEF provides cost-efficient ground-testing capabilities for a multitude of programs across the DoD, commercial systems and aircraft.

ACETEF supports installed systems testing in a warfare environment using state-of-the-art stimulation and simulation technology. It also has a combination of laboratories that offer risk-reduction, compliance check and system performance for aircraft, their systems, and the warfighter. These laboratories provide realistic open-loop and/or closed-loop multi-spectral environment stimulation to Electronic Warfare (EW), sensor, communications, navigation and identification systems during both developmental and operational testing.

ACETEF is the T&E center of excellence for Modeling and Simulation (M&S) of the modern Battlespace environment behaviors and interactions. It provides credible, repeatable models of highly complex, interactive and reactive environments as well as scenario development and UAS expertise. The facilities utilize and support multiple warfare environment models and is the developer of two government-owned, license-free, mission-level models that support acquisition decision, warfare analysis, aircraft/aircraft systems, ground testing evaluation, and training.

ACETEF has the flexibility to create custom, real-time data displays and data gathering systems to aid customers in extracting the data they require from ground test events. The team's capabilities range from performing system simulation, providing ground-test support and stand-alone testing on installed aircraft Electronic Warfare (EW), Navigation (NAV), and Communication (COM) systems.

ACETEF operates a number of shielded and anechoic test facilities on the East and West Coast which provide a secure, uncontaminated RF environment to perform testing on installed avionics and handheld equipment. From a Boeing 707 sized aircraft to microchips, the facilities accommodate test vehicles at any size.

CAPABILITY SUMMARY

Shielded Hangar

- Has surrounding labs that provide uninterrupted realistic signals to systems under test
- Provides a controlled, secure and realistic test environment for system stimulation
- Accommodates multiple platforms
- Built to accommodate multiple large aircraft
- Wire mesh covered doors and walls, enabling Electromagnetic Environmental Effects (E3) testing, TEMPEST and COMSEC certification, and electronic warfare suite integration
- Provides a secure and realistic test environment for system stimulation
- Has access to three major runways

Aircraft Anechoic Test Facility (AATF)

- 100'L x 60'W x 40'H
- Designed for tactical size aircraft and helicopters
- Overall signal attenuation in the chamber is greater than 100 dB over a frequency range of 140 kHz to 40 GHz
- Has surrounding labs that provide uninterrupted realistic signals to systems under test

Advanced Systems Integration Laboratory (ASIL)

- Anechoic Chamber test Area: 180'L x 180'W x 60'H (32,000 square feet of floor testing area)
- Can accommodate two tactical aircraft (up to 40 tons) or one E-6 or Boeing 707 sized aircraft.
- Chamber isolation (15 kHz – 40 GHz) is specified as 100 dB. Maximum reflectivity of the RAM varies from -3 dB at 30 MHz, to -45 dB at 37 GHz.
- "U-shaped" pit under the chamber floor for stimulation equipment; signal cables are passed through ports in the floor
- Preparation area between chamber door and weather door keeps temperature on chamber door steady to prevent warping and provides additional area for testing
- The Operations Control Center (OCC) provides an area where tests can be controlled and viewed and is accessible to networks, simulator displays and SUT cameras

Electromagnetic Interference (EMI) Chambers

- 3 full anechoic chambers
  - 20' x 15' x 10'
  - 24' x 20' x 10'
  - 24' x 15' x 10'
- 1 mode stir chamber
- 20' x 16' x 10'

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A.6.4 Electromagnetic Test Capability

TEST RESOURCE CATEGORY

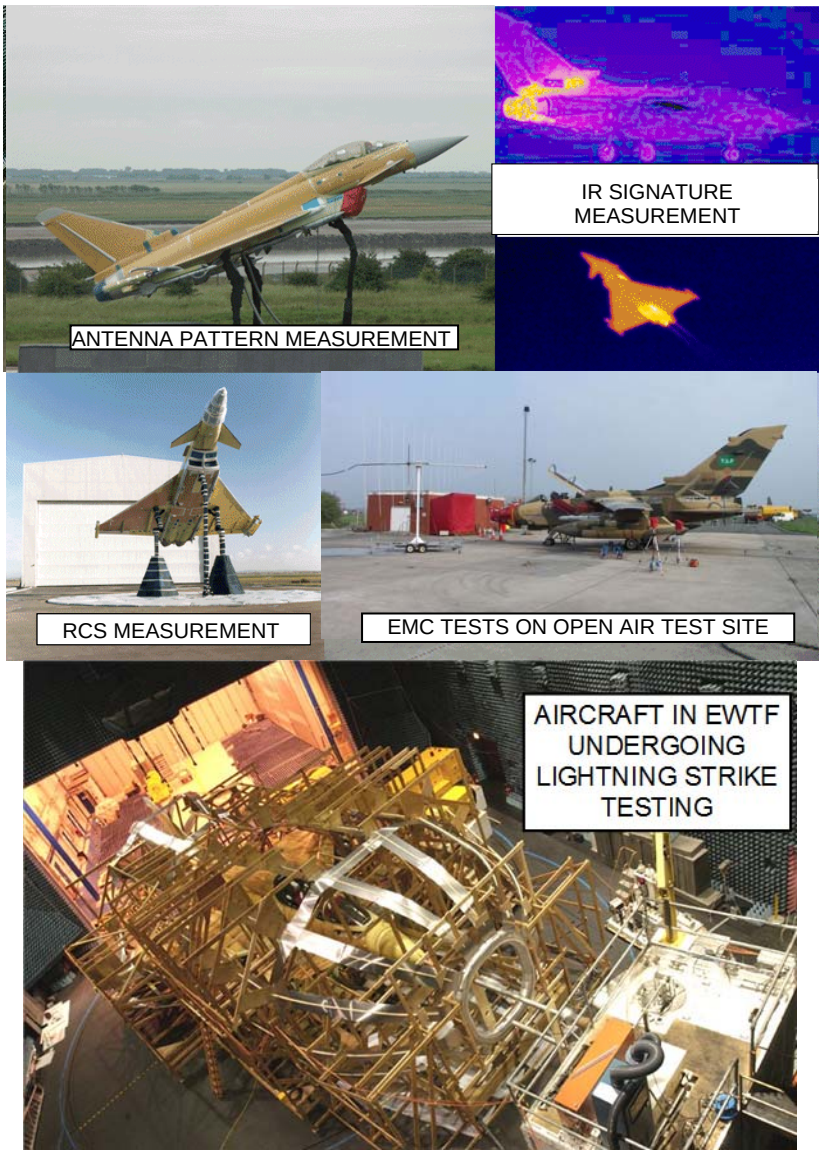
Primary: ISTF / Other: MF.

LOCATION

BAE SYSTEMS, Military Air Solutions, Warton, Lancashire, UK.

NARRATIVE DESCRIPTION

The Electromagnetic Test Capability spans the disciplines of EM Hazards (EMC/EMI), Lightning strike simulation, Signatures (RCS/IRS) and Installed Antenna Testing. To allow realistic full threat testing of whole aircraft platforms the ISTF includes a dedicated outdoor High Intensity RF (HiRF) Radio Environment Generator (REG) facility, a low power CW swept illumination facility for platform characterisation, a RF- and laser-shielded anechoic chamber (used for both HiRF and lightning strike testing), along with an outdoor RCS range. Additionally a range of smaller laboratories, some RF screened, are available for component and sub-systems testing.



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The key benefit of most of the facilities is the ability to 'drive in' fully integrated platforms, from small UAVs to large combat aircraft. In particular the ability for many of the facilities to support platforms fully powered with 'live' Flight Control Systems and engines on, provides the most representative ground test environment. The figures show tests being performed in the various test facilities. The majority of the test capability has been developed with mobility in mind and testing has been performed around the World. With this mobility it is possible to test larger platforms on open field sites, customer bases and in hangars.

CAPABILITY SUMMARY

EM Hazards EMH/EMI

REG Facility Equipment

16 kW solid state 10 kHz – 200 MHz CW amplifier
1 kW solid state 100 – 1000 MHz CW amplifier

- Up to 50 V/m 5 – 30 MHz (at 15 m)
- > 200 V/m 30 – 200 MHz (at 5 m)
- > 450 V/m 200 MHz – 1 GHz (at 1 m)
- Targets up to 15 m

Microwave Test Capability

Minimum CW Capability			
Frequency (GHz)	Minimum Field Strength Level (V/m)		
1 – 18	614		
Minimum Pulsed RF Capability			
Frequency (GHz)	Peak Field (V/m)	PRF (kHz)	Pulse Width (µs)
1 – 2	2000	1	30
2 – 4	3883	1	25
4 – 8	3883	1	25
8 – 12.4	5000	1	30
12.4 – 18	2000	1	30

- Low Level Swept Characterisation (LLSC) 2 MHz – 400 MHz
- Bulk Current Injection (BCI) 2 – 400 MHz
- Bay attenuation 200 MHz – 18 GHz

Signatures (RCS/IRS)

RCS Measurement Range

- 2 – 18 GHz frequency coverage
- Full polarisation H, V and cross-polar
- Absolute RCS data, 1D and 2D imagery
- Platforms/targets up to 35 tonnes
- Targets up to 15 m in extent
- 7 m tall, 12 tonne Az/El low-RCS positioner

Mobile RCS Measurement System

- 2 – 18 GHz frequency coverage
- Test articles from component to whole body targets of 12 m in size
- Measure target in early and mid lifecycle, production stage and in service

IRS Measurements

- MWIR (1.5 – 5.5 µm) and LWIR (7 – 11.5 µm) thermal imaging cameras
- Measurements from -20°C to +1500°C
- Ground-to-ground, ground-to-air, air-to- ground and air-to-air capabilities
- Building/industrial equipment thermal surveys

Installed Antenna Pattern Measurements

- Use of outdoor RCS range
- 360 degrees turntable
- Performance verification of:
  - Direction of Arrival (DoA)
  - Effective Radiated Power (ERP)

Lightning Strike Simulation

- Any arbitrary shot amplitude from 200 kA full threat down to 20 kA sub-full threat
- Aircraft return conductor solutions up to 40 m x 40 m
- Anechoic chamber solution for platforms up to 16 m wide and 12.5 m high

Microwave Materials Measurement

- 100 MHz – 20 GHz frequency coverage
- Co- and cross-polarisations, complex relative permeability and permittivity, reflectivity
- S-parameters and surface wave attenuation
- 7 mm co-axial, free-field focussed beam, open-ended co-axial probe and NRL arch

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A.6.5 Anechoic Shielded Chamber

TEST RESOURCE CATEGORY

Primary: ISTF / Other: MF.

LOCATION

Alenia Aeronautica S.p.A., Caselle South Plant, Turin, ITALY.

NARRATIVE DESCRIPTION

The Anechoic Shielded Chamber (ASC) is the Alenia Aeronautica state-of-the-art testing facility designed to perform Electromagnetic Compatibility measurements and High Radio Frequency (RF) Sensitivity tests in a protected environment from both RF external noise and adverse weather conditions.

The Anechoic Shielded Chamber is a fully anechoic facility that allows to perform, in a controlled environment, both Intra- and Inter-system, such as EMC and High Intensity Radiated Field verification, in a representative environment of free-space, i.e., equivalent to actual flight conditions, and according to applicable civil and military standards.

The ASC is also provided with equipment for performing Antenna Radiation Pattern measurements and is suitable for Electronic Warfare (EW) tests.

The Anechoic Shielded Chamber is included in the same Host Building with another major facility: the Sky Light Simulator, the most advanced aerospace lighting laboratory in the world.

The Anechoic Shielded Chamber is composed of four shielded environments: an Anechoic Shielded Chamber (ASC), a Shielded Control Room/Amplifier Room 1 (SCR/AR1), an Electronic Warfare Chamber (EWC) and a Reverberating Chamber.

A Preparation Room located in front of the ASC Main Access Door, represents a protection against atmospherics and a comfortable area for aircraft setting up before the test campaign.

Remote management of the Anechoic Shielded Chamber is possible inside the Shielded Control Room (SCR) where the test execution in comfortable, automatic and safe condition is assured by: HIRF power generation control and monitoring system, CCTV system equipped with five cameras installed at different height and an infrared camera.

The Anechoic Shielded Chamber is designed to perform EMC/HIRF and RF testing on fighter aircraft as Eurofighter, Tornado, M-346 but it is also suitable for: small civil aircraft, rotorcraft, spacecraft, EW pod

and weapon system such as missile, ground vehicle and system. Moreover, the Anechoic Shielded Chamber is approved by the IT NSA as a TEMPEST test facility for platform/system.

CAPABILITY SUMMARY

Anechoic Shielded Chamber • Anechoic chamber and several shielded test laboratories • Offices, conference rooms • Secure facilities (tailored to program requirements)	**Chamber Dimensions** • Shield: 30 m long x 30 m wide x 20 m high • RAM-tip to RAM-tip: 26 m x 26 m x 16 m • Main door: 18 m wide x 8.5 m high • One 2.5 m wide x 2.5 m access door • One human-sized access door
Shielding • Shielding > 100 dB from 200 kHz to 18 GHz • TEMPEST grade, fully welded shield • Quiet zone 10 m diameter, 6 m high • Anechoic frequency range: 30 MHz -18 GHz	**Support Services** • 30 ton 10 m diameter turntable can rotate the system under test +/- 180 degrees up to 1 deg/sec. • One 25-ton hoist • Aircraft electrical power: • 400 Hz, 115 VDC, 3Ø (General) • Instrumentation power: 28 VDC, etc. • Cooling air system • Hydraulic system
EMI/HIRF • 10 kW solid state 9 kHz – 100 MHz CW amplifier • 4 kW solid state 100 MHz – 1000 MHz CW amplifier • 1 kW solid state 1 – 18 GHz CW amplifiers • 2 kW TWT 1 – 18 GHZ PW amplifiers • Low Level Swept Characterisation (LLSC) 30 MHz – 400 MHz • Bulk Current Injection (BCI) 10 kHz – 400 MHz • Low level swept field/bay attenuation 30 MHz – 40 GHz • Emission radiated and conducted test 2 MHz – 18 GHz	**Installed Antenna Pattern Measurements** • NF-FF test facility using spherical • Performance verification of: • Effective Radiated Power (ERP) **Microwave Materials Measurement** • 100 MHz – 20 GHz frequency coverage • Co- and cross-polarisations, complex relative permeability and permittivity, reflectivity • S-parameters and surface wave attenuation

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A.6.6 Electromagnetic Open Area Test Sites

TEST RESOURCE CATEGORY

Primary: ISTF / Other: MF.

LOCATION

Alenia Aeronautica S.p.A., Caselle South Plant, Turin, ITALY.

NARRATIVE DESCRIPTION

The **Electromagnetic Test Centre** is mainly involved in ElectroMagnetic Compatibility / High Intensity Radiated Field (**EMC/HIRF**) qualification and certification of aircraft products that Alenia Aeronautica designs autonomously, such as the last generation of UAV technological demonstrators Sky-X and Sky-Y or, more frequently, in partnership with other national or international aerospace industries. The most recent aircraft like C-27J Spartan, Eurofighter Typhoon and Alenia Aermacchi M-346 have been tested and certified by Alenia's Electromagnetic Test engineers using the **Open Area Test Sites** with proprietary test instrumentation.

The main activities of the Alenia Aeronautica **Electromagnetic Test Centre** are: to evaluate the electromagnetic compatibility and susceptibility aspects in system integration, to test and verify the satisfaction of EMC and HIRF requirements of complex platform, to perform final tests to demonstrate the fulfilment of International Standard requirements for Certification purposes, to test and check the RF performance of sub-systems integrated into air vehicle (e.g., navigation aids equipment), to test and check the performance of emitter devices directly installed on the aircraft (e.g., antenna radiation pattern), to support the testing activities defining the appropriate test instrumentation and facilities based on new testing requirements, to deal with EMC issues developing dedicated test instrumentation, new facilities and/or testing methods, with the aim to keep the technical know-how updated at the state-of-the-art.

The **EMC Test Range** is a dedicated open area (around 5,400 m^2) including two circular test areas of 15 m diameter for vertical and horizontal polarization HF radiation; the **EMC Test Range** is equipped with a turntable platform that allows full 360° aircraft rotation.

The **Transport Test Area** was built at the beginning of 2001 specifically for the certification of the C-27J transport

aircraft. The result is a dedicated open area (50 m x 50 m), in which it was possible to perform the EMC tests with and without engines running that supported the civil certification of the C-27J in June 2001.

Various **Mobile Test Stations** are working in both OATS, each provided with RF instrumentation, tools and PCs to conduct EMC/HIRF testing in flexible, comfortable and safe manner.

Both Open Area Test Site are equipped with all the necessary ancillary system to provide electrical and hydraulic feed to air vehicles during the measurement campaign.

CAPABILITY SUMMARY

Open Area Test Site: • Three testing locations for both horizontal and vertical polarization • Offices, conference rooms	**Test Site Dimensions:** • EMC Test Range: 5400 m^2 with two testing locations • Transport test aircraft range: 50 m x 50 m
EMI/HIRF: • 20 kW solid state 1 – 30 MHz CW amplifier • 10 kW solid state 9 kHz – 100 MHz CW amplifier • 4 kW solid state 100 MHz – 1000 MHz CW amplifier • 1 kW solid state 1 – 18 GHz CW amplifiers • 2 kW TWT 1 – 18 GHZ PW amplifiers • Low Level Swept Characterisation (LLSC) 1 MHz – 400 MHz • Bulk Current Injection (BCI) 10 kHz – 400 MHz • Low level swept field / bay attenuation 1 MHz – 40 GHz • Emission radiated and conducted test 2 MHz – 18 GHz	**EMC Test Range Support Services** • 30 ton 8 m diameter turntable can rotate the system under test +/- 180 degrees up to 1 deg/sec. • One 25-ton hoist • Aircraft electrical power: • 400 Hz, 115 VDC, 3Ø (General) • Instrumentation power: 28 VDC, etc. • Hydraulic system • Ground plane • Wooden platform (h 3.0 m) • Fixed antennas (5 ÷ 30 MHz) • Mobile antennas (30 MHz ÷ 40 GHz) • Shielded test stations
	Transport Test Range Support Services • Aircraft electrical power: • 400 Hz, 115 VDC, 3Ø (General) • Instrumentation power: 28 VDC, etc. • Hydraulic system • Dedicated trolley for aircraft rotation • Fixed antennas (2 ÷ 30 MHz) • Mobile antennas (30 MHz ÷ 40 GHz) • Shielded test stations

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A.6.7 USAF Joint Pre-Flight Integration of Munitions and Electronic Systems (J-PRIMES)

TEST RESOURCE CATEGORY

Primary: Installed Systems Test Facility (ISTF).

LOCATION

Eglin AFB, FL, USA.

NARRATIVE DESCRIPTION

The J-PRIMES anechoic chamber, as an Installed Systems Test Facility (ISTF), provides testing of air-to-air and air-to-surface munitions and electronics systems on full-scale aircraft and land vehicles prior to open air testing. Through simulation and modelling, vast amounts of performance data can be obtained at a fraction of the time and cost of conventional flight test programs alone.

(Image: USAF/Samuel King Jr.)

CAPABILITY SUMMARY

J-PRIMES Provides The Following Major Test Areas:

RF Anechoic Chamber

- 100 dB RF-isolated anechoic chamber with a hoist lift capacity of 40 tons and capable of testing all current USAF, USA, and USN fighter aircraft and helicopters, a variety of ground combat vehicles, and numerous commercial platforms

Outdoor Ramp

- Open-air flight line area for testing of large aircraft, with access to all facility simulation and instrumentation

Test Stations

- Shielded laboratories for sub-system level testing of fighter and bomber electronics and weapon systems

EMI/EMC Chamber

- Semianechoic shielded enclosure for testing of MIL-STD 461/462 and many other EMI/EMC commercial specifications

J-PRIMES Instrumentation Includes:

- AMES II for simulation of threat radar signals
- Four target, closed loop radar target simulator with dynamic radar cross-section, jet engine modulation, electronic countermeasures, and clutter signatures used to simulate threat engagement scenarios
- MIL-STD-1760 weapons and aircraft simulator for interfacing with aircraft systems
- Two 10-channel differential GPS constellation and GPS jammers

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A.6.8 CASSIDIAN EME Test Facility

TEST RESOURCE CATEGORY

Primary: ISTF: Whole System EM Testing.

LOCATION

CASSIDIAN, Manching, GERMANY.

NARRATIVE DESCRIPTION

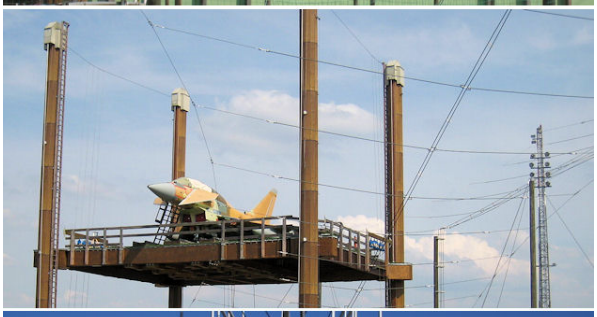
The Cassidian EME Test Facility is a full threat level, 5 – 30 MHz HIRF test facility and provides individually tailored testing for EME qualification, verification and certification support for military and civil customers, for large and operational systems.

EME testing is performed according to national, international, military, NATO and civil standards, as well as customer defined requirements. Supporting activities such as test definition, test vehicle monitoring and data evaluation are available.

An RF transparent, rotatable, heavy duty wooden lifting platform is available to eliminate ground effects and to ensure a large and homogeneous test volume. Additionally, mobile HIRF test facilities up to 18 GHz are available, to support on site testing at customer locations. The facility has excellent antenna decoupling and interference measurement capabilities. State-of-the-art Test Equipment is used throughout.

EM Testing is typically performed when the certification authorities require re-testing due to modifications on a system (e.g., due to changes in cabling, new electronic/electrical equipment, changes due to obsolescence), or when a type certification of a system or sub-system is required by the certification authorities, or when an engineering test is required to reduce the risk due to EMC related failures, as well as when EMC failures have occurred during normal operation.

Some of the systems already tested include the Eurofighter TYPHOON, the Panavia TORNADO, the F-4F PHANTOM, the C-160 TRANSALL, the P-3C ORION CUP, as well as the NH90 TTH and the CH53GA helicopters.



CAPABILITY SUMMARY

Application Examples

- Small to large system testing, with mobile test equipment
- Type certification for German flight clearance authorities (ML)
- Shielding effectiveness measurement of all kinds of objects
- Conducted and radiated emission measurements of all kinds of objects, including with running engines
- Antenna pick up, noise, phase decoupling and installed performance measurements
- Direct (DCI) or indirect current injection into all kinds of structures

Electromagnetically Transparent Wooden Elevation Platform:

- Raising of test objects up to 20 m into the homogenous zones of horizontal polarized EM fields
- Platform load max. 30 t, turn range ±182°
- Large test volume: Vertical polarised (40(l) x 35(b) x 12(h) m); Horizontal polarised 20 x 15 x 6 m

HIRF Test Capabilities

- 5 – 30 MHz up to 250 V/m (100 kW)
- 30 – 500 MHz up to 250 V/m (2 – 5 kW)
- 0,5 – 1 GHz up to 650 V/m (2 kW)
- 0,8 – 18 GHz up to 1000 V/m (350 W)

Direct Current Injection (DCI)

- To support low frequency HIRF testing on complex systems

Low Level Swept Current (LLSC) Testing

- 1 – 400 MHz, 64 current probes in parallel, ultra fast measurement technique

Low Level Swept Field (LLSF) Testing

- 5 MHz – 18 GHz, up to 12 field probes in parallel

Bulk Current Injection (BCI)

- 10 kHz – 400 MHz, multi-injection

Enhanced Level Injection into onboard sensors

- 10 kHz – 18 GHz, all modulation types

Standards

- All IEC, EN, DIN standards
- All MIL-STDs
- All VG standards
- All STANAG standards
- Customer specific

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A.7 OPEN AIR RANGES, INCLUDING EW T&E FLIGHT TEST CAPABILITIES

A.7.1 Electronic Combat Range

TEST RESOURCE CATEGORY

Primary: OAR / Other: HITL.

LOCATION

China Lake, California, USA.

NARRATIVE DESCRIPTION

The Electronic Combat Range (ECR) is physically located in California at China Lake's South Range and provides a realistic electronic combat environment. ECR provides threat systems; operations and range control; instrumentation; Time, Space, Position Information (TSPI), telemetry, optical and communications; data processing and display systems; and signal monitoring, calibration systems and assessment and repair facilities for test and evaluation and training customers. The ECR is the Navy's principle open-air range for test and evaluation of electronic combat systems.

Threat Simulations

The ECR offers a wide variety of threat simulations, surrogates and actual systems, providing a threat-rich environment. The 1,200 square miles of restricted airspace overlying 900 square miles of Navy land offer ample room for either single- or multi-platform events.

Open-air hardware-in-the-loop testing at the ECR helps bridge the gap between laboratory and open-air testing. Long before a system is ready for flight testing, the hardware can be tested against an assortment of threat systems and advanced technology simulators.

Multiple threat systems are available: actual, surrogate and simulated. A broad range of EW technologies are offered: pulse, continuous wave, Doppler, multi-spectral, and Blue and Gray systems. Test emitter spectrums include radio frequency, electro-optical and millimeter wave. All systems use audio and video instrumentation to collect extensive digital flight test data.

Test Support

At ECR, aircrew have the opportunity in a single mission to combat both an air-to-air threat and a surface-to-air threat as well as complete an air-to-ground strike mission.

Top secret and special-access level security is available with minimum electromagnetic interference. ECR supports a combination of land and naval systems (littoral threat). The ECR provides engineering support, developmental and operational test and evaluation, analysis, and training resources for users of systems that counter or penetrate air defences.

CAPABILITY SUMMARY

Types of Events	**Technologies**
• Electronic Countermeasures (ECM) effectiveness testing • Radar Warning Receiver (RWR) testing • Unmanned Aerial Systems (UASs) • Expendables – chaff and flare effectiveness • Towed and air launch decoy testing • Anti-Radiation Missile (ARM) flight testing to evaluate seekers and avionics • Tactics development • Training	• Pulse systems • Continuous wave systems • Pulse Doppler systems
Data Outputs	**Systems Provided**
• Scope video • Boresight video • Display video • Radio recordings • Crew hot mike recordings • Digital data • Raw unprocessed data • Sorted corrected data (wild point flags and sorted by time)	• Advanced threat simulations • Surrogates • Red, blue, and gray threat assets

POINT OF CONTACT

Electronic Threat Systems
7000 Randwash Road
China Lake, CA 93555, USA
Tel: 760-939-5303
www.navair.navy.mil/ranges

A.7.2 Vidsel EW Test Range

TEST RESOURCE CATEGORY

Primary: OAR / Other: EW-Training Range.

LOCATION

Vidsel Test Range is located in the northern part of Sweden, almost on the Arctic Circle and close to Vidsel Airbase (ESPE).

NARRATIVE DESCRIPTION

Vidsel Test Range is operated by the Swedish Defence Materiel Administration (FMV) and is best known for its large overland capability and for its weapon employments. At Vidsel Test Range it is possible to undertake Air-to-Air firing with large stand-off weapons, to employ various live bombs and also to operate UAV flights.

In recent years EW has become a key factor in the development of the range. During the NATO Loyal Arrow exercise (2009) and in other international air exercises Vidsel Test Range has provided realistic EW threats. Since Vidsel Test Range and the surrounding Restricted Area is so large, vertically and horizontally, it's very well suited for large scale training or for tests that require large space.

The Swedish Armed Forces have performed tactical testing at Vidsel of their equipment and flight crews against IR/UV threat simulators.

Foreign air forces have conducted a tactical EW-training course with helicopters at Vidsel Test Range using generic RF threats as well as IR/UV simulators.

The Swedish aircraft industry has also used IR/UV simulators to do tests of Missile Approach Warning Systems (MAWS).

CAPABILITY SUMMARY

Range Area • The total range area where we can employ weapons is approximately 35 x 70 km and this area can be evacuated if needed.	**Airspace** • The Airspace (Restricted Area / ESR02) surrounding the range area is approximately 70 x 120 km laterally and unlimited vertically. Vidsel Test Range 'owns' the airspace which makes it possible to use the air very flexibly.
Infrastructure • Vidsel Test Range has excellent infrastructure with fibre and RF links, networks, road networks, electrical power networks, airfield, range instrumentation systems and much more. There is also a structure in which different kinds of threat systems can be connected in many various locations. This structure is connected to a real-time control system, VIEWS by CAS, UK, in the main mission control center. Post mission evaluation (quick feedback to air crews) is also done in/with this system.	**Airbase** • Vidsel Test Range is supported by Vidsel Airbase (ESPE) located approximately 30 km from the southeast corner of the Range Area. The airbase is fully operational with a 7300 ft runway equipped with an arresting cable. **IR/UV** • Vidsel Test Range has two Mallina systems which simulate IR/UV threats (SA-7). These simulators are very flexible for use as tactical threats and can also be used to verify MAWS and flare systems.
RF • Vidsel Test Range can offer three tracking radar units as generic RF-emitters for testing or tactical training.	**Flares** • Vidsel Test Range allows the use of flares at all levels in the range area (depending on the level of fire hazard).
Chaff • Vidsel Test Range allows the use of chaff.	**EW-Jamming/GPS-Jamming** • Vidsel Test Range allows EW and GPS jamming (subject to approval from the authorities).

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A.7.3 Center for Countermeasures (CCM)

TEST RESOURCE CATEGORY

Primary: OAR / Other: N/A.

LOCATION

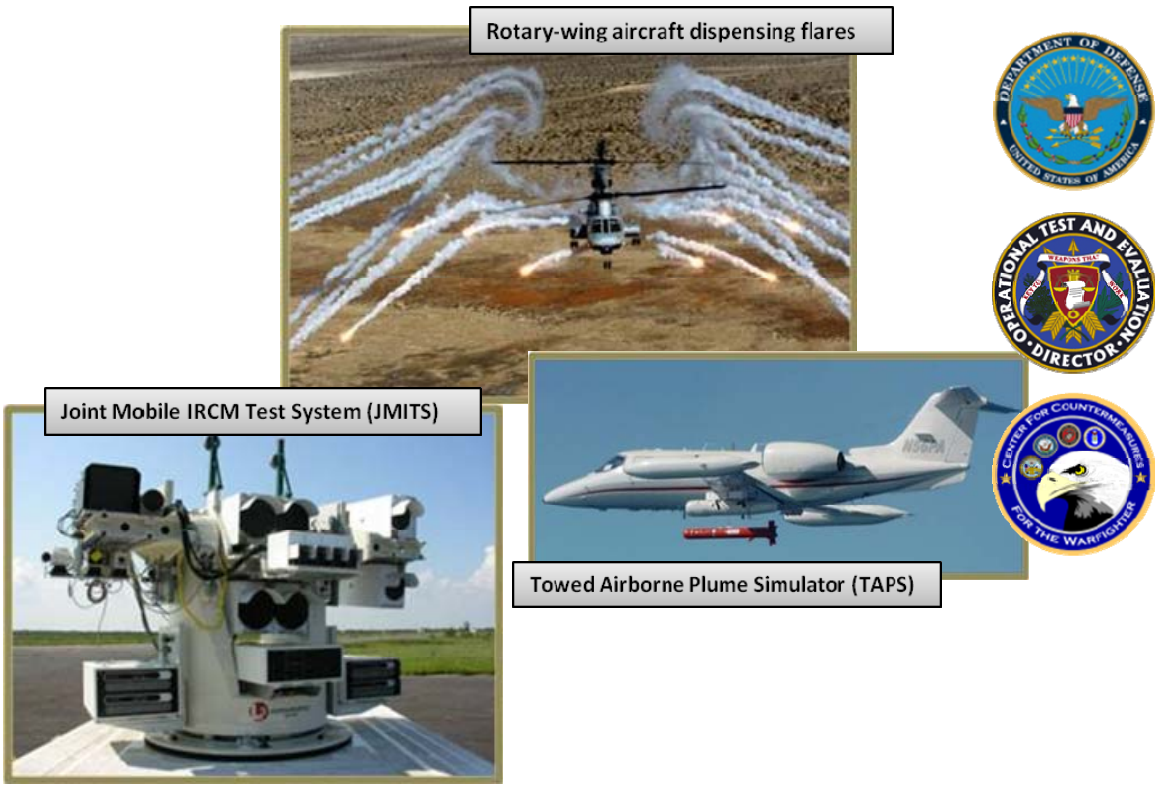
White Sands Missile Range, New Mexico, USA.

NARRATIVE DESCRIPTION

The Center for Countermeasures (CCM) directs, coordinates, supports and conducts independent Countermeasure (CM) / Counter-Countermeasure (CCM) test and evaluation activities for U.S. and foreign weapon systems, sub-systems, sensors and related components. We are a tenant organization at White Sands Missile Range and report to and receive guidance and funding from the Office of the Secretary of Defense, Director, Operational Test and Evaluation.

The Center supports all of the Services and other federal agencies in their test activities by having world-class organization for open air IRCM T&E, providing Survivability Equipment (SE) with an emphasis on rotary and fixed wing platforms, providing Hostile Fire (HF) data collection and activity coordination, and offering threat injection during pre-deployment events.

The Center provides many unique capabilities including mobile, self-sufficient T&E equipment; zero labor cost providing significant savings to the program; independent CM/CCM assessments at anytime in the program's acquisition cycle; and establish and maintain US-NATO survivability memorandums of agreement.



CAPABILITY SUMMARY

Types of Events: • Independent counter-countermeasure test and evaluation • Zero labor cost providing significant savings to the program • Independent CM/CCM assessments at anytime in the program's acquisition cycle • Establish and maintain US-NATO survivability memorandums of agreement	**Technologies**: • Threat injection during pre-deployment events
Data Outputs: • Hostile fire data collection	**Systems Provided:** • Mobile, self-sufficient T&E equipment • Survivability equipment with an emphasis on rotary and fixed wing platforms

POINT OF CONTACT

Center for Countermeasures
Tel: 575-678-7200

A.7.4 NATO Joint Electronic Warfare Core Staff

TEST RESOURCE CATEGORY

Primary: OAR / Other: N/A.

LOCATION

Main Operating Base is at RNAS Yeovilton, UK; however all assets are mobile and deployable as required throughout the NATO AOR.

NARRATIVE DESCRIPTION

NATO Joint Electronic Warfare Core Staff (JEWCS) has a number of functions including provision of a hostile EW environment in which to conduct training at the tactical and operational levels in the land, maritime and air environments for all NATO standing and assigned forces. (This includes a remit to support EW trials and experimentation). It also supports Operations, provides the NATO Emitter Database (NEDB) and provides NATO's core EW staff function, EW policy and doctrine.

The JEWCS EW training capability is applicable to EW T&E Flight Testing and can provide: Radar and communications emitter simulation, Radio communications intercept, jamming and deception, Radar jamming and deception, Datalink jamming and EMCON and COMSEC monitoring. These capabilities are provided by assets operating in the air sea and land environments, any of which could be utilised in Flight Testing. The fundamental difference between the JEWCS assets and those on a more traditional EW range is that the assets are all mobile or transportable and routinely deploy to the location required throughout the NATO AOR. It should be noted however that because of equipment limitations and training artificialities the power levels of the equipments are not calibrated and are not usually representative of operational systems.

A brief description of the EW assets is as follows:

- **EW Pods –** ALQ-167 pods which can be carried on contractor business jet type aircraft such as DA-20 Falcon or Learjet, or on suitably certified fast jets, currently only F18, F4 and Hawker Hunter. 8 radar simulation pods and 24 Jamming pods. Effective for both air to air and air to ground jamming and Simulation.

- **TRACSVANs –** (TV) Transportable Radar and Communications Jamming and Simulation Vans TV. Optimised for maritime EW but also usable in other scenarios. They are capable of simultaneous radar jamming, radar simulation, datalink jamming and communications jamming/deception. The TV can be deployed at sea on host-ships or can deploy on land operating off a transporter. Capable of ground to air, although for radar jamming and simulation it has very limited capabilities for optically tracking fast moving (airborne) targets.
- **MINI-RADARVAN (MRV) –** Vehicle capable of radar simulation and jamming, including DRFM. Capable against surface or airborne targets; however it is primarily intended for use against fixed surface targets, tracking capability is very limited.

- **SHORT RANGE AIR DEFENCE SITE SIMULATOR (SAD) –** Capable of simulating radars associated with Surface-to-Air Missile systems or Anti-Aircraft-Artillery systems. Targets are acquired and tracked visually through binoculars.
- **UV MALLINA SYSTEM (MALLINA) –** Capable of short range stimulation of UV Missile Warning Systems.
- **NATO EW VANs (NEWVAN – NV) –** Optimised for Land EW, but also usable for amphibious and air exercises. Provides Comms ESM, jamming and deception.
- **NI NEWVAN (MNV) –** Landrover-based capabilities similar to NV.
- **MOBILE INTERCEPT JAMMING ASSETS (MIJA) –** Off-road capable communications assets which can provide ESM intercept, jamming and deception.

CAPABILITY SUMMARY

- ALQ-167 pods.
- Simulation:
  - Banded frequency range: 7.8 to 17.5 GHz, PRF 200 – 6000, PW 0.1 to 2.0 µSec, stable, jittered and staggered PRF modes. Jamming: noise and coherent (DRFM) techniques. Banded frequency range: 0.85 to 17.2 GHz.
- MRV radar simulation and jamming (non-coherent and coherent techniques) 0.85 GHz – 18 GHz. V/UHF comms.
- SAD. Bands 7.8 – 8.5, 8.5 – 9.5 and 14.5 – 15.2 GHz. PRF 200 – 5500 (stable or random jitter or stagger).
- UV Mallina. Library modes for test MAWS/DASS (AN/AAR-47, AN/AAR-54, AN/AAR-57, AN/AAR–60, MAW-200)
- NEWVAN, Mini NEWVAN and MIJA. Surveillance/DF 2 – 1000 MHz, Jamming 2 – 1000 MHz (capabilities vary)

POINT OF CONTACT

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A.7.5 T&E Support for Aircraft Survivability

TEST RESOURCE CATEGORY

Primary: OAR / Other: N/A.

LOCATION

Eglin Air Force Base, Florida, USA.

NARRATIVE DESCRIPTION

The 46th Test Wing (46 TW) provides complete end-to-end Test and Evaluation (T&E) capability for aircraft self-protection systems and threat system performance in support of aircraft survivability and vulnerability studies.

Extensive target signature measurement capability provides calibrated data across the full electromagnetic spectrum and operational environment. Flexible airborne and ground instrumentation platforms allow measurement of all surface and airborne targets. These target signatures are used to develop and validate digital signature models for virtual missile to target engagements. For example, simulated Infrared (IR) and Electro-Optical (EO) target models can be developed using Spectral and In-band Radiometric Imaging of Targets and Scenes (SPIRITS), Composite Hard-body and Missile Plume (CHAMP), and Real-Time CHAMP (RTC) software. Red and blue missiles seekers can engage these virtual targets in a non-destructive HITL simulation. With extensive land and water ranges and a wide variety of test instrumentation assets, the 46 TW provides a unique open-air capability to evaluate sensors and seekers against real-world targets in realistic air, land, and sea background test and training scenarios. Open-air assets include the Missile Warning Sensor Stimulator, the Seeker Test Van, the STEF, and a variety of flight certified pod-based platforms. The 46 TW has a great deal of experience planning and conducting tests of aircraft self-protection systems against heat-seeking missiles, and has been an instrumental team member in almost all major IR protection programs including: the Large Aircraft IR Countermeasure System (LAIRCM), the Directed IR Countermeasure System (DIRCM), Advanced Threat IR Countermeasures System (ATIRCM), and Advanced Strategic Tactical Expendable Program (ASTE). These programs span self-protection applications across many diverse types of aircraft and operational users.

CAPABILITY SUMMARY

SEEKER TEST VAN (STV)

The Seeker Test Van (STV) is an aid in the development and exploitation of the Guidance and Control Units (GCUs) of ground-to-air and air-to-air missiles, the assessment of countermeasures effectiveness, techniques, and tactics in an open-air test environment.

- Collects data on up to six GCUs simultaneously
- Three seeker control stations (each controlling two seekers)
- A data acquisition station, a video and data recording station, a data reduction station, and a mission control station
- KTM has five mounting surfaces for seekers, visible cameras, Infrared (IR) cameras/radiometers, and a Mallina Missile Warning System (MWS) stimulator/simulator
- Employs a missile roll fixture to create a realistic test scenario for rolling airframe missiles

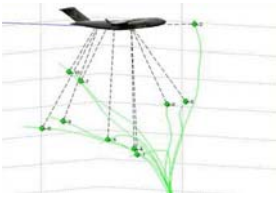
Typical instrumentation suite for testing aircraft missile warning systems

GUIDED WEAPONS EVALUATION FACILITY (GWEF)

The GWEF provides multi-spectral simulations for test and evaluation of precision-guided weapons, threat systems, and countermeasure systems. A complete range of T&E capability is available including digital simulation, HITL simulation, parametric measurements, countermeasure testing, and performance characterization assessment. The GWEF is the only facility of its kind able to test the complete spectrum of weapon seekers and sensors under one roof.

- Digital and Hardware-In-The-Loop (HITL) simulations of air armament munitions
- Parametric measurements
- Countermeasure (CM) testing
- Directed Energy (DE) countermeasure effectiveness testing against MANPADS
- HITL testing incorporates full imaging capability of aircraft targets via leading edge technology of resistor arrays
- Provides virtual test range for multi-mode sensors including millimeter wave, imaging infrared, and semi active laser

Simulated MANPADS trajectories with no countermeasures



Simulated MANPADS trajectories with active countermeasures

EGLIN MOBILE MISSILE LAUNCHER SYSTEM (EMMLS)

EMMLS provides live launch capability for Man-Portable Air-Defence Systems (MANPADs) against real or simulated aircraft.

- EMMLS consisting of a positioned, a control vehicle and a generator to power the system
- EMMLS is capable of firing both foreign and domestic MANPADS
- EMMLS operates both a generic positioner on a portable trailer for testing shoulder-fired MANPADS, and a simulated threat Transporter/ Erector/Launcher (TEL) for larger surface-to-air missiles
- The control van operates the launchers and can record missile diagnostic signals, position information, video (infrared and visible), referenced to IRIG time

Live MANPADS launch from EMMLS

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A.7.6 Trials/Test Support Group

TEST RESOURCE CATEGORY

Primary: OAR / Other: Equipment and Personnel.

LOCATION

ESL Defence Ltd, 16 Compass Point, Ensign Way, Hamble, Southampton, Hampshire, UK.

NARRATIVE DESCRIPTION

The Trials/Test Support Group has extensive experience in operating long range Electro-Optical/Infrared (EO/IR) threat simulators to perform test and evaluation of Aircraft Survivability Equipment (ASE). This support is provided by Subject-Matter Experts to assist with the planning and operation of the threat emitters either those deployed on the open-range or leased as part of the support exercise.

The Trials/Test Support Group can also provide the service of data collection and data analysis and provide a Final Report from this data. One of the major contributors to the success of performing a test and evaluation exercise is to ensure that the probability of declaration from the various ASE sensors threat is high and if possible 100 percent. To achieve this high probability with today's high technology sensors requires a combination of representative missile signatures and operator experience in the understanding of the limitations of the threat emitter when fired at a moving target. The Trials/Test Support Group Engineers with their many years of international experience of stimulating many different types of missile warning system can provide the required expertise.

In addition, and perhaps of equal importance, is the performance of the EO/IR threat emitters. ESL has developed a comprehensive range of high fidelity long range threat emitters. These threat emitters include both UV and IR Emitters, known as Mallina and Phoenix, for the test and evaluation of UV and IR missile warners, laser warning receivers and for providing simulation of muzzle flash for the simulation of Hostile Fire Indicators. Further, by combining these threat emitters with additional EO/IR modules, including an IR Detector to measure the output from the DIRCM countermeasure, an end-to-end evaluation of a DIRCM system can be performed by what is known as the Mallina DIRCM Cluster. Further, the Trials/Test Support Group can provide a comprehensive set of flight line test sets that can test the aircraft just prior to the test and evaluation flight to ensure that the system under test is operating correctly.

UV LED Mallina

IR Phoenix

DIRCM Mallina Cluster

CAPABILITY SUMMARY

Trials/Test Support Activities

- The Trials Support Group comprises a number of subject-matter experts in simulation of missile and hostile fire for the simulation of aircraft survivability equipment. This support can be provided to operate either the open-range legacy equipment or ESL's comprehensive portfolio of threat emitters that can be provided on a lease basis. The support includes:
  - Pre-test and evaluation programme planning
  - Aircraft flight test path planning
  - Development of optimised missile profiles for use in the threat emitters
  - Operation of the threat emitters
  - Training of range operational staff
  - Trails data collection
  - Analysis of trials data
- In addition to the above, ESL can provide flight line test equipment to test the System Under Test (SUT) to establish just prior to the test flight, on a "Go/No-Go" basis, that the SUT is functioning correctly. The flight line test equipment portfolio comprises:
  - Solent – to test omni directional IR Jammer
  - UV and IR Baringa – to test UV and IR missile warners respectively
  - Hydra – to test laser warning receivers
  - MEON to perform an end-to-end test of a DIRCM system
  - Multi-spectral test set – to test ASE equipment that requires simultaneous multi-spectral stimuli

Support Hardware and Software

- The EO/IR threat emitters simulators available for lease comprise:
  - UV and IR Griffen – to stimulate UV and IR missile signatures at ranges in excess of 5 km
  - UV LED Mallina – to simulate UV missile warners and UV hostile fire indicators (muzzle flash only) at ranges in excess of 8 km
  - Red and Blue HP Phoenix – to simulate IR missile warners and IR hostile fire indicators (muzzle flash only) at ranges in excess of 3 km
  - IRM-16 IR Beacon and Detector Module – to provide an IR beacon for the DIRCM fine tracking system to lock on to and measure the characteristics of the DIRCM countermeasure beam
  - Mallina Laser Range Finder Module – to provide a means to establish the range of the SUT and if selected auto-selection of the appropriate profile for that range
  - Tripod Legs and Head – to support the threat emitters.
  - Threat Emitter Management Software Tools – to download profiles into the threat emitter and remotely operate the threat emitters from a Desk-top PC or Laptop
  - Missile Signature Development Tools – to provide missile signatures based on public domain missile data

POINT OF CONTACT

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