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14. ABSTRACT Modern day military aircraft depend on a diversity of electromagnetic sensors to provide both aircraft and pilot with unparalleled battle space awareness and engagement opportunity. Missions involving reconnaissance, search and rescue, time vision navigation/evasion, target acquisition, target search and track, missile warning, and terminal missile homing all require the most advanced sensors available to provide the war fighter with the greatest possible tactical advantage. The latest generation of military aircraft rely heavily on these multispectral sensors as an integrated component of the flight control and mission control avionics. Often, overall mission performance is directly linked to the combined performance of the onboard mission critical sensors. Therefore, exhaustive sensor testing in this integrated sensor/avionics environment is mandatory.					
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HIGH FIDELITY INSTALLED SENSOR TESTING USING AN INFRARED SCENE PROJECTOR

by Richard Robinson and Tom Joyner

Modern day military aircraft depend on a diversity of electromagnetic sensors to provide both aircraft and pilot with unparalleled battle space awareness and engagement opportunity. Missions involving reconnaissance, search and rescue, time vision navigation/evasion, target acquisition, target search and track, missile warning, and terminal missile homing all require the most advanced sensors available to provide the war fighter with the greatest possible tactical advantage. The latest generation of military aircraft rely heavily on these multi-spectral sensors as an integrated component of the flight control and mission control avionics. Often, overall mission performance is directly linked to the combined performance of the onboard mission critical sensors. Therefore, exhaustive sensor testing in this integrated sensor/avionics environment is mandatory.

Installed Sensor Testing

Verifying the interoperability of the avionics/sensor group is required to determine the overall mission performance of the aircraft. This testing is best accomplished with the unit-under-test (UUT) sensor installed on the system-under-test (SUT) aircraft. The highest fidelity of systems performance testing occurs during flight testing. However, providing a mission representative environment in flight is becoming increasingly cost prohibitive. Therefore the aviation community is developing ground based capabilities for testing sensor subsystems while installed on the host aircraft (i.e., Installed Sensor Testing).

IRSS Program

Under Office of the Secretary of Defense (OSD), Central Test and Evaluation Investment Program (CTEIP) sponsorship, the Navy and Air Force are jointly developing Joint Installed System Test Facility (JISTF)

upgrades that are based on simulation and stimulation technologies. Current development includes the Infrared Sensor Stimulator (IRSS), Generic Radar Target Generator (GRTG), and Joint Communications Simulator (JCS).

The Navy is integrating these three stimulator systems in its Air Combat Environment Test and Evaluation Facility (ACETEF) at the Naval Air Warfare Center - Aircraft Division (NAWC-AD), Patuxent River, MD. The ACETEF integrated test capability enables simultaneous testing of the aircraft sensor suite under simulated operational flight scenarios in a cost effective virtual/simulated environment. ACETEF capabilities include two anechoic chambers (the larger chamber shown in photo) for installed aircraft testing.

The IRSS system will be used to stimulate *installed* Infrared/Ultraviolet (IR/UV) Electro-Optic (EO) sensors undergoing integrated developmental and operational testing.

The IRSS will provide the capability to test multiple sensors such as Forward looking Infrared (FLIR), Missile Warning Systems (MWS), Infrared Search and Track (IRST) and Missile Seekers installed on the SUT aircraft.

Unique Requirements

As depicted in the adjacent figure, the Navy ACETEF consists of the multiple stimulator system drivers separated from the emitters and injectors in the anechoic chamber and/or hangar with the UUT/SUT. Three different stimulation techniques will be utilized to simultaneously test multiple sensors. These techniques are free space radiation for testing RF sensors, scene projection for testing EO/IR/UV



Navy ACETEF Anechoic Test Chamber: F/A-18C and EA-6B suspended.

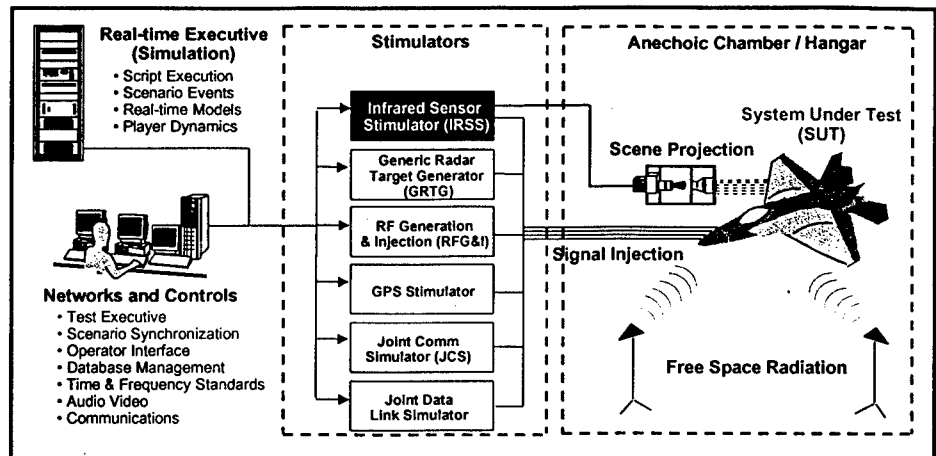
sensors, and signal injection. The technique of signal injection bypasses the sensor transducer and directly injects an electronic signal into the sensor processing electronics. Signal injection is often utilized when it is not possible (for cost or logistics reasons) to stimulate a sensor with in-band radiated energy.

Free space radiation and scene projection provide the greatest level of test fidelity by stimulating the entire sensor system (e.g., transducer, processing electronics/algorithms) with the test scenario. Operating in an RF environment presents several challenges to testing EO sensors. These challenges include: 1) Long distance between the IRSS control room, simulation components and anechoic chamber; 2) Operation of IR test equipment/electronics in the noise rich RF chamber environment; 3) Attachment of an IR scene projector to a suspended aircraft without compromising airframe integrity; and 4) Attachment of the projector to aircraft without introducing a significant amount of RF reflective surface material.

In the past, these constraints have limited the test engineer to the following options: 1) Not perform simultaneous RF/IR sensor testing; 2) Perform lower fidelity IR signal injection, bypassing the sensor detectors and optics; or 3) Remove and remote test the sensor in an adjacent IR test lab. While viable options for many tests, each of these solutions compromises the ability to test under a true tactical aircraft configuration.

High Resolution Sensors

Most IR installed sensors are imaging infrared (I^2R) sensors, that produce a raster output image similar to that of a video camera. The major types of I^2R sensors are staring and scanning. Scanning sensors utilize a mechanical assembly to optically sweep a detector array across the desired field of view to form an image. A scanning example is the Infrared Search and Track (IRST) sensors used to scan the horizon for other aircraft. However, the simplicity of the staring infrared focal plane array elevates them as the preferred sensor for most aircraft applications. The high



Simultaneous RF/IR Installed Sensor Testing Utilizing Free Space Radiation, Signal Injection, and Scene Projection.

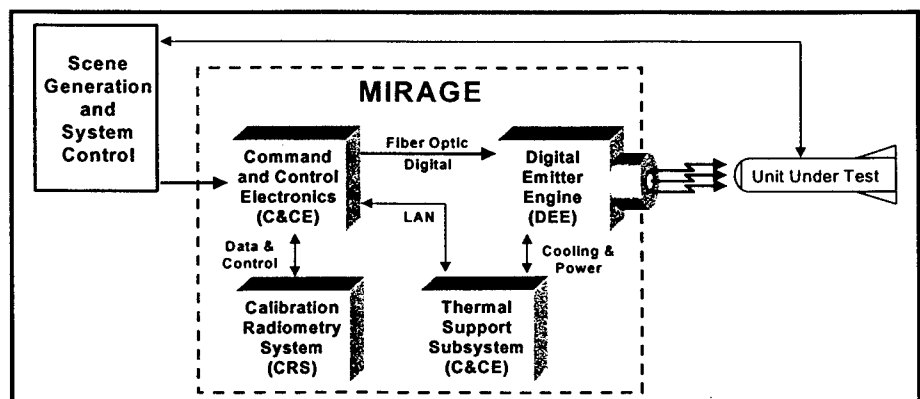
resolution imagery capability of these sensors enables their employment in mission critical applications such as target acquisition and target tracking. Most often these images are analyzed in real-time by onboard processors which are simultaneously analyzing the information from other sensors to gain a more complete picture of the surrounding battle space (i.e., sensor fusion, target correlation). Therefore, critical to evaluating aircraft mission performance against a wide range of real-world tactical scenarios is the need to present dynamic high resolution IR scenes to the I^2R sensors while simultaneously stimulating the other onboard sensors.

A New Approach

In response to the foregoing requirements, the IRSS program selected the MIRAGE (Multi-spectral InfraRed Animation and Generation Equipment) dynamic infrared scene projectors to stimulate its installed I^2R sensors. The MIRAGE system is built by Santa Barbara Infrared (SBIR) and

accepts digital (Silicon Graphics Onyx2 DVP2/DDO2) or analog (RS170/NTSC/PAL) video input, and delivers a high-fidelity infrared scene to the entrance aperture of the sensor under test. The difficulties and risk of system integration have been mitigated by SBIR's product-oriented turnkey approach to the MIRAGE design. Consequently, the end user can better focus on testing deliverable hardware, rather than trying to create and debug a scene projector from disparate, unmatched components.

The fundamental component of the MIRAGE scene projector is its advanced micro-emitter array. This state-of-the-art integrated circuit is constructed of thermally isolated mechanical structures with deposited thin film resistive heaters, fabricated on an advanced sub-micron silicon read-in integrated circuit (RIIC). Digital to analog (D/A) converters, row and column addressing, and unit cell buffers are all integrated on-chip, with a pure digital data interface to the RIIC. Unlike other projectors, the



MIRAGE is a Complete Turnkey Infrared Scene Projector with 512x512 Resolution.

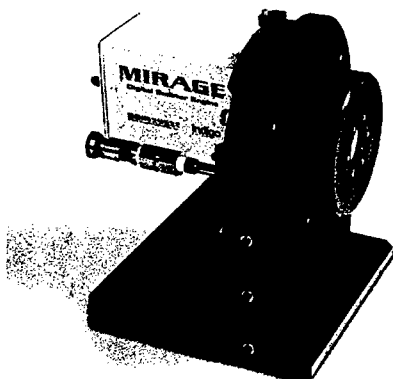
MIRAGE has no need for a bulky, noisy digital to analog electronics chassis. A proprietary pixel unit cell resistor drive circuit design minimizes thermal and electrical crosstalk, provides for uniform current distribution, minimizes output noise, and maximizes the overall dynamic range of the MIRAGE scene simulator.

The Digital Emitter Engine (DEE) is a compact, lightweight, rugged enclosure for the emitter array and its support electronics. The DEE comprises of a vacuum dewar for the emitter, a heatsink for emitter cooling, local regulation for power supplies, a fiber optic receiver for scene data, and a precision kinematic mount for the optical interface. Input to the DEE is DC power and refrigerated coolant (from the Thermal Support Subsystem), and scene digital data (via a fiber optic line from the Command and Control Electronics).

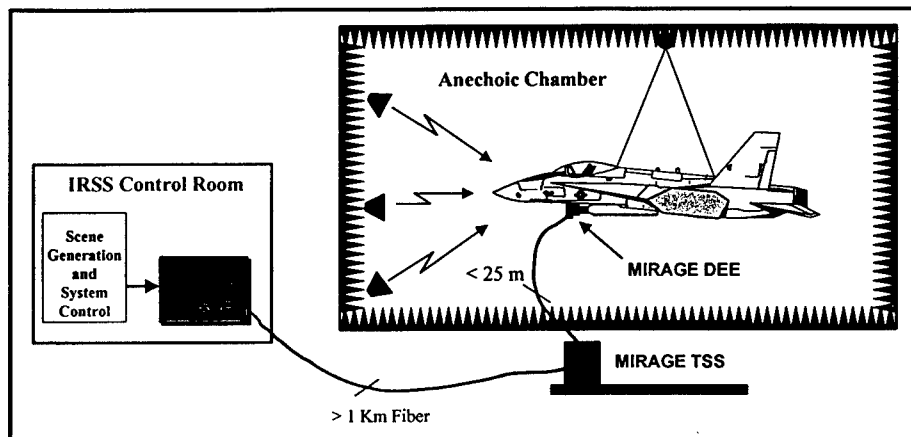
A Windows NT graphical user interface provides a central control panel for system configuration and operation. The GUI automates the complex setup and sequencing of the instruments within the MIRAGE system as it moves from its initial power-on state through real-time operation. The straightforward interface greatly reduces the load on the operator, prevents any inadvertent damage to the hardware, and provides continuous system status and built-in-test reporting. Overall, the MIRAGE is designed to be a very user friendly, modular, plug-n-play type IR system.

Expanded Capabilities

The turnkey nature of the MIRAGE has enabled the ACETEF integrators to concentrate on the unique



MIRAGE Digital Emitter Engine



Fiber Optic Interfaces, Modular Design, and Compact, Light Weight DEE allow for Distributed Installation on an Aircraft or Flight Motion Simulator.

facility/SUT/UUT interface issues rather than the development of the projector. Several of the innovative features of the MIRAGE have resulted in expanded test capabilities for installed IR sensors. The modular design of the MIRAGE and the fiber-optic interface between the Command and Control Electronics (C&CE) and Thermal Support System (TSS) will permit IRSS designers to separate the MIRAGE subsystems by over 1km, as illustrated above. The user interface station and C&CE are located in the IRSS control room while the TSS and DEE will be located in the anechoic chamber. In addition to providing a long distance interface capability, the fiber optic digital scene data interface provides the necessary noise immunity for operation in an active RF environment.

The compact size and light weight of the DEE provides two other important advantages. At only 11 inches long by 8 1/2 inches in diameter and 16 pounds in weight, the DEE (along with the optics) can be attached directly to the suspended aircraft without compromising the integrity of aircraft structural components. The other important advantage of the compact DEE is minimal additional RF reflecting surface, which may be important during RF sensor testing.

The current DEE utilizes a 512x512 resistive emitter array, adequate for testing most current generation I²R sensors. However, emitter arrays of much higher spatial resolution will be needed to test the next generation of I²R sensors. This requirement for scalability leads to perhaps the most

innovative feature of the MIRAGE. Since it is fabricated on a commercial CMOS integrated circuit line, the MIRAGE emitter RIIC substrates may be "stitched" together to build emitter arrays of larger formats (e.g., 1024x1024 and 1024x2048). SBIR and its emitter design team are presently in the process of designing these next generation IR emitter arrays. Early prototypes of these LAISE™ (Large Area Infrared Scene Emitter) arrays are slated for fabrication in 2001.

The MIRAGE scene projectors are scheduled for installation in the IRSS facilities during the summer of 2000 with the overall IRSS enhancement scheduled for Full Operating Capability in the fall of 2000.

Meet the Authors

Richard Robinson is the Director of Scene Simulation at Santa Barbara Infrared Inc. (SBIR), manufacturers of advanced EO/IR test equipment and scene simulation systems. (robinson@sbir.com) Tom Joyner is a Principal Systems Engineer at COMTEK-PRB Associates, Inc. and is employed on-site at the ACETEF as the Program Manager for development of the IRSS component of the JISTF enhancement program.