Real-time Threat Emulator – Synthetic Environment Testing for the Common Missile Warning System (CMWS)

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Real-time Threat Emulator (RTE) Overview

- An integrated system that provides a simulated flight environment for controlled, repeatable testing of the Common Missile Warning System (CMWS)
- Injects recorded imagery from an actual flight directly into the system to replace the incoming sensor data
- Provides synchronized inertial, imagery, and navigation data to the aircraft
- “Fools” the CMWS into believing it is in simulated flight by exploiting a test mode in CMWS

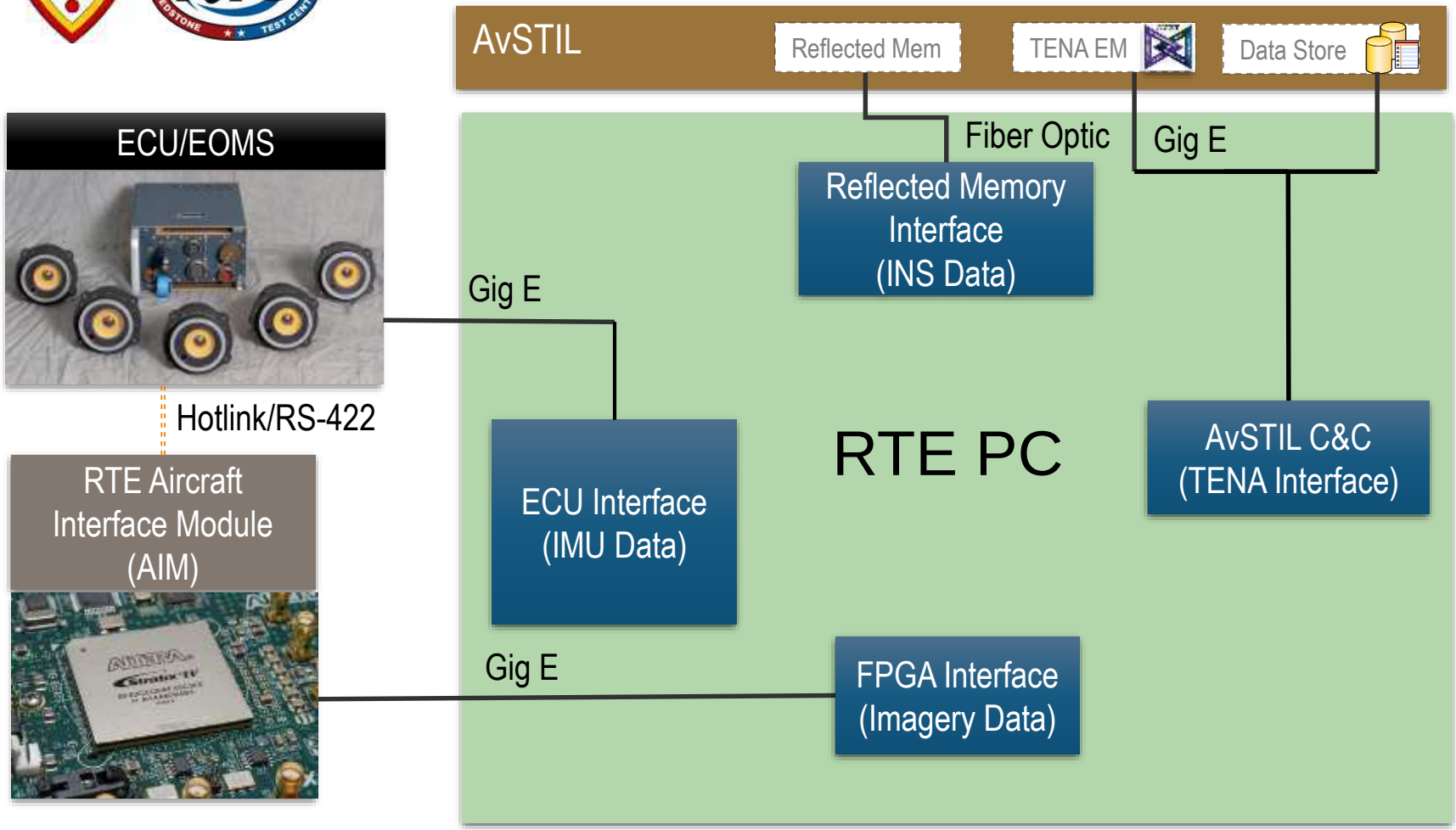
Why RTE? Addressing the challenges of Flight Testing

- Flight testing presents a variety of logistical challenges
- Flight testing is heavily dependent on weather conditions
- Flight testing is prohibitively expensive
- Flight Testing presents many independent variables that are not repeatable from one flight to another, making it difficult to evaluate differences in hardware and software of systems under test

Redstone Test Center Aviation System Test and Integration Lab (AvSTIL)

- Uses real data recorded from actual flights, along with models and simulations, to create virtual flight scenarios
- Controlled via Test and Training Enabling Architecture (TENA) interface, which provides integration with other AvSTIL components
- By driving data buses and stimulating sensors and other interfaces, AvSTIL performs virtual flight testing of aircraft systems without the difficulties and costs of actual flight tests, and with faster turn-around between tests
- RTE is an automated part of AvSTIL for testing the Common Missile Warning System (CMWS)

RTE System View



RTE Aircraft Interface Module

- Field Programmable Gate Array (FPGA)-based electronics, HOTLink® and RS-422 transceivers, Gigabit Ethernet
- CMWS Electronics Control Unit (ECU) polls optical sensors for imagery via RS-422, sensors reply via HOTLink®, a point to point messaging standard
- FPGA receives decompressed imagery frames via Ethernet packets, then intercepts incoming sensor imagery and replaces with recorded or simulated data

RTE Aircraft Interface Module (cont.)

- Can also combine incoming sensor data with recorded sensor data. This allows an external projector to inject potential threats into a sensor's input optics, and have those threats overlayed on the recorded data
- Scenario creation: recorded imagery shows a known background, test engineer can project virtual threats into the sensors, and RTE fuses the virtual and recorded data to allow for limitless scenario possibilities

RTE Aircraft Interface Module (AIM)

RTE Inertial Measurement Unit (IMU) and Inertial Navigation System (INS) Injection

- Recorded IMU and INS data must also be injected along with imagery because the ECU must believe it is in simulated motion and in the correct navigational position in order to respond to incoming threats properly
- IMU data is injected into ECU via Ethernet, and the ECU syncs the IMU data with the imagery
- INS data is injected via 1553, and is time-synced to the IMU and imagery data by controlling a 1553 bus overdriving device via reflected memory.

RTE Imagery Decompression

- A 6 sensor system operating at maximum frame rate generates approximately 1.1 GB of raw imagery every minute
- The CMWS compresses the data when recording it using a lossless compression scheme with variable length messages from each sensor
- Decompressing this data is a time-intensive exercise, taking up to one quarter of the length of the playback file to process

RTE Imagery Decompression (cont.)

- For this reason, decompression of the recorded imagery is done in real time using a multicore workstation and 16 GB of RAM
- Before beginning a scenario, the selected imagery file begins preprocessing into a buffer. As the scenario commences, decompression continues, keeping the buffer full enough to ensure that the AIM box always has imagery to inject

RTE Imagery Decompression (cont.)

- Significant efforts have been made to optimize decompression algorithms and look-up tables, allowing real time decompression that would otherwise be impossible
- Through extensive testing to date there have been no data underflows

RTE Integration with AvSTIL

- Scenario is loaded by AvSTIL operators. Buffers on PC side are filled, along with buffers in AIM box
- TENA command to begin execution is sent, which starts the AIM box as well as the IMU and INS data injection
- The RTE PC ensures that all of the data remains in sync by controlling the flow of each data stream during playback
- RTE can also be operated independent of AvSTIL infrastructure

RTE Integration with AvSTIL (cont.)

- At the conclusion of the scenario, the RTE returns to an idle state, ready for the next scenario
- Completely autonomous operation through integration with AvSTIL TENA architecture
- Passed acceptance testing conducted by Project Manager for Instrumentation, Targets and Threat Simulators (PM ITTS) in July 2015
- Successfully used to test systems on UH-60M, AH64D/E, and CH-47F platforms

Summary

- **FUNCTION** - RTE plays back recorded data from actual flight tests to “fool” aircraft into believing that it is in simulated flight rather than on the ground
- **COST SAVINGS** - Eliminates many logistics, environmental, and repeatability issues associated with flight testing
- **CUSTOMER SUPPORT** - Provides Redstone Test Center with an important capability in the support of Aircraft Survivability Equipment testing
- **NEW CAPABILITIES** - Fusing virtual models with actual recorded data; compression and decompression algorithm optimization; precision synchronization of disparate data sources