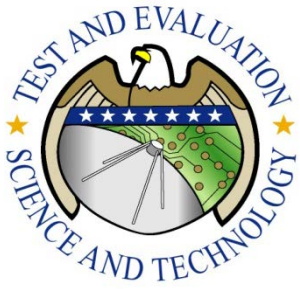

Test and Evaluation/Science and Technology Program

Live Virtual Constructive Technologies for Test (LVCT)

ITEA 2017

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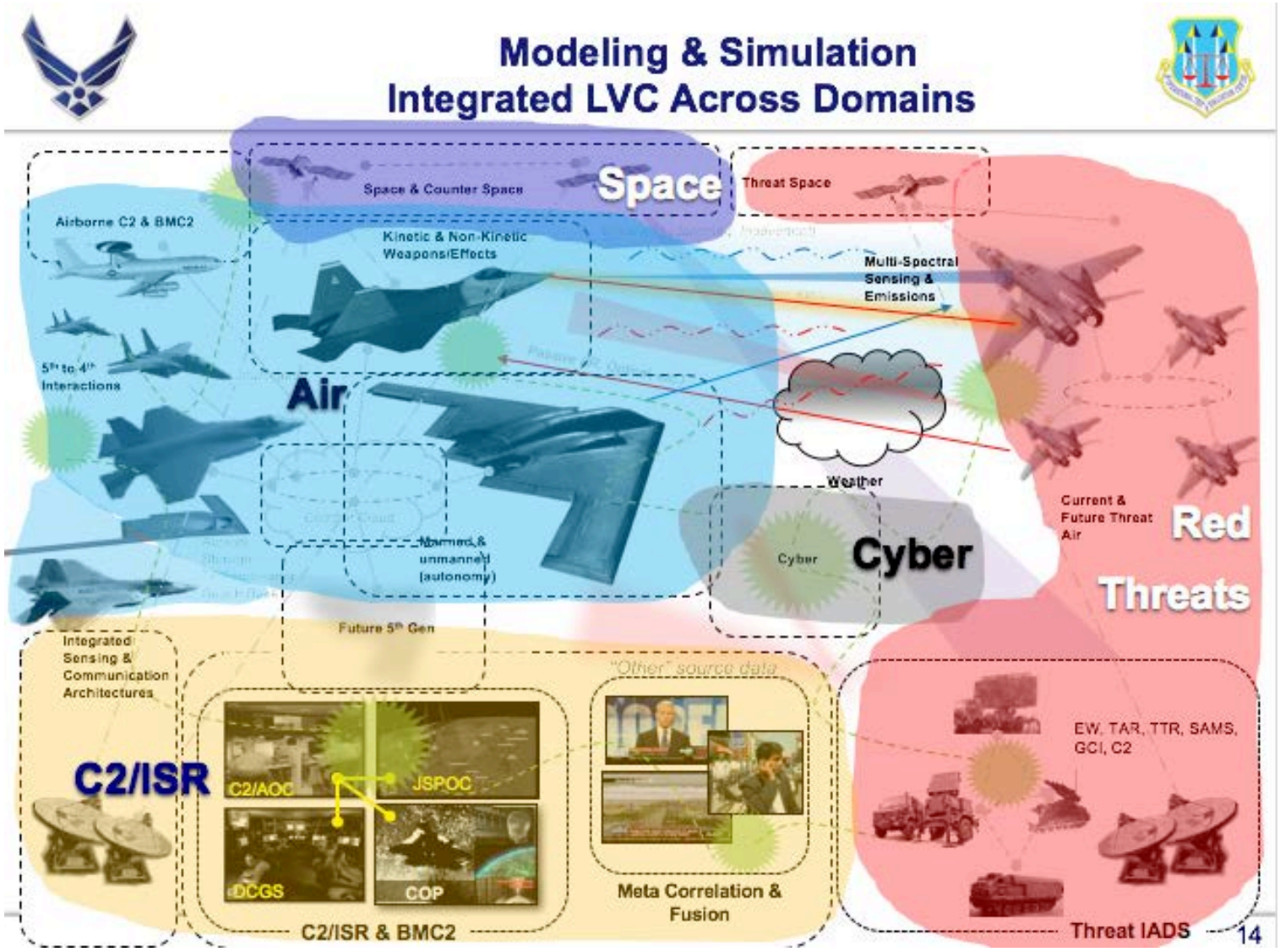
Outline

- **Provide an LVCT Program Overview**
  - Architecture and Technologies
  - Phase 1 Test
  - Phase 2 & Transition
- **Potential Enhancements**

PROGRAM OVERVIEW

Why LVCT? Technologies Can Be Leveraged Across Many Domains



** Maj. Gen. Malloy presentation at the 33rd ITEA Symposium

LVCT Program Vision

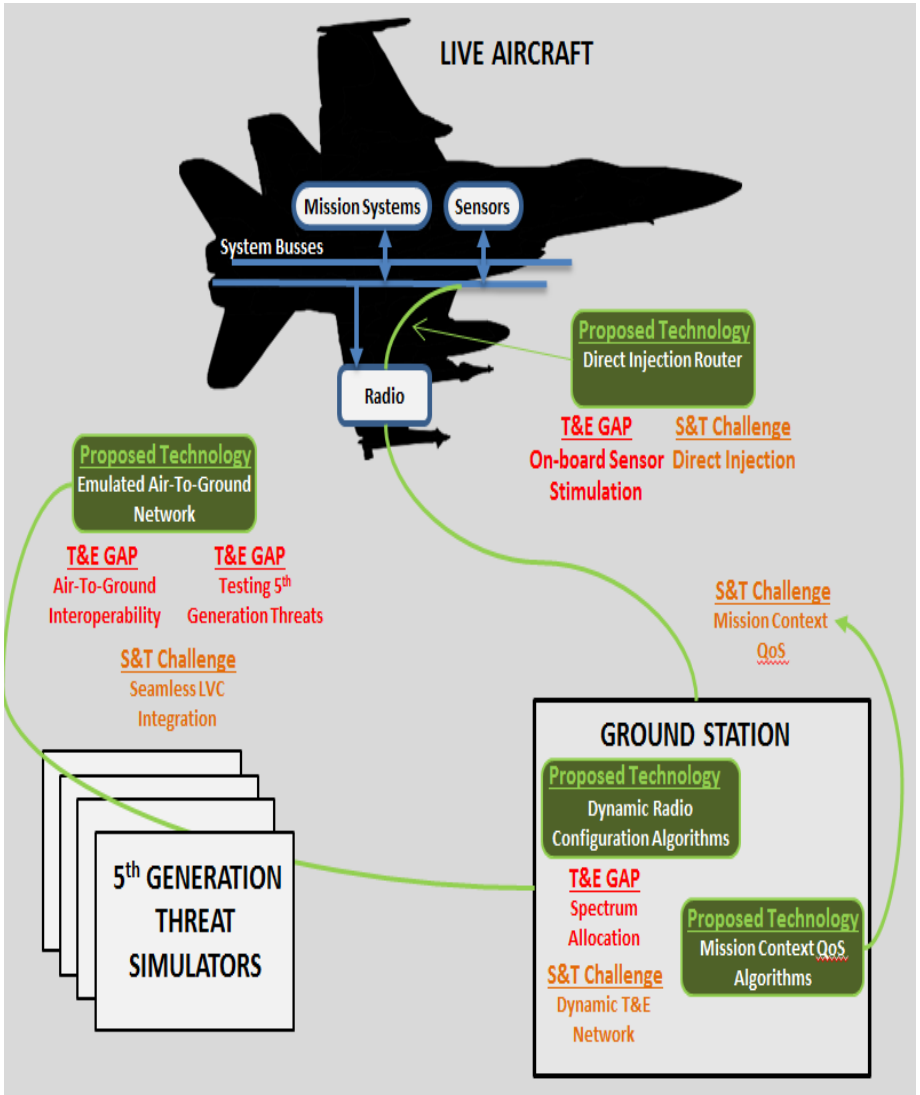
- **Integrate Live Systems with Synthetic in Order to:**
  - Deliver a complex, realistic test environment to test advanced/next generation platforms and weapons
  - Cost-effectively test sophisticated and networked platforms and weapons across a wide variety of missions
  - Develop reusable/reconfigurable technologies to meet the fidelity required to support mission based objectives.
  - Test Earlier and Often in Contested Environments – Look for Opportunities for Developmental Test (DT) as well (systems and sensors)

LVCT Problem Description

- **T&E Need**
  - Testing 4th and 5th Generation Aircraft Against 5th Generation Threats – Few Range Systems Replicate 5th Generation Threats (Simulation Can Address the Gap)
  - Air to Ground Interoperability within LVC Environment – Need for a Rich Data Set and Integration with Mission Systems and Sensors (Wireless)
- **S&T Challenge**
  - Direct Message Injection – Creating Software Patterns that Support Mission System & Sensor Awareness of Simulated Data
  - Mission Context Quality of Service (QOS) – Create a scalable and reliable wireless data link through QOS algorithms that support message prioritization and channelization thus conserving bandwidth
  - Dynamic T&E Network – Merging Mission Requirements with the Communications Infrastructure (Waveforms, Spectrum Utilization)
  - Seamless LVC Integration – Providing a “plug and play” architecture that permits V&V of the simulated representation of the real world.
  - Address Waveform and Platform Variety – develop an architecture that supports heterogeneous waveform requirements between different platforms.

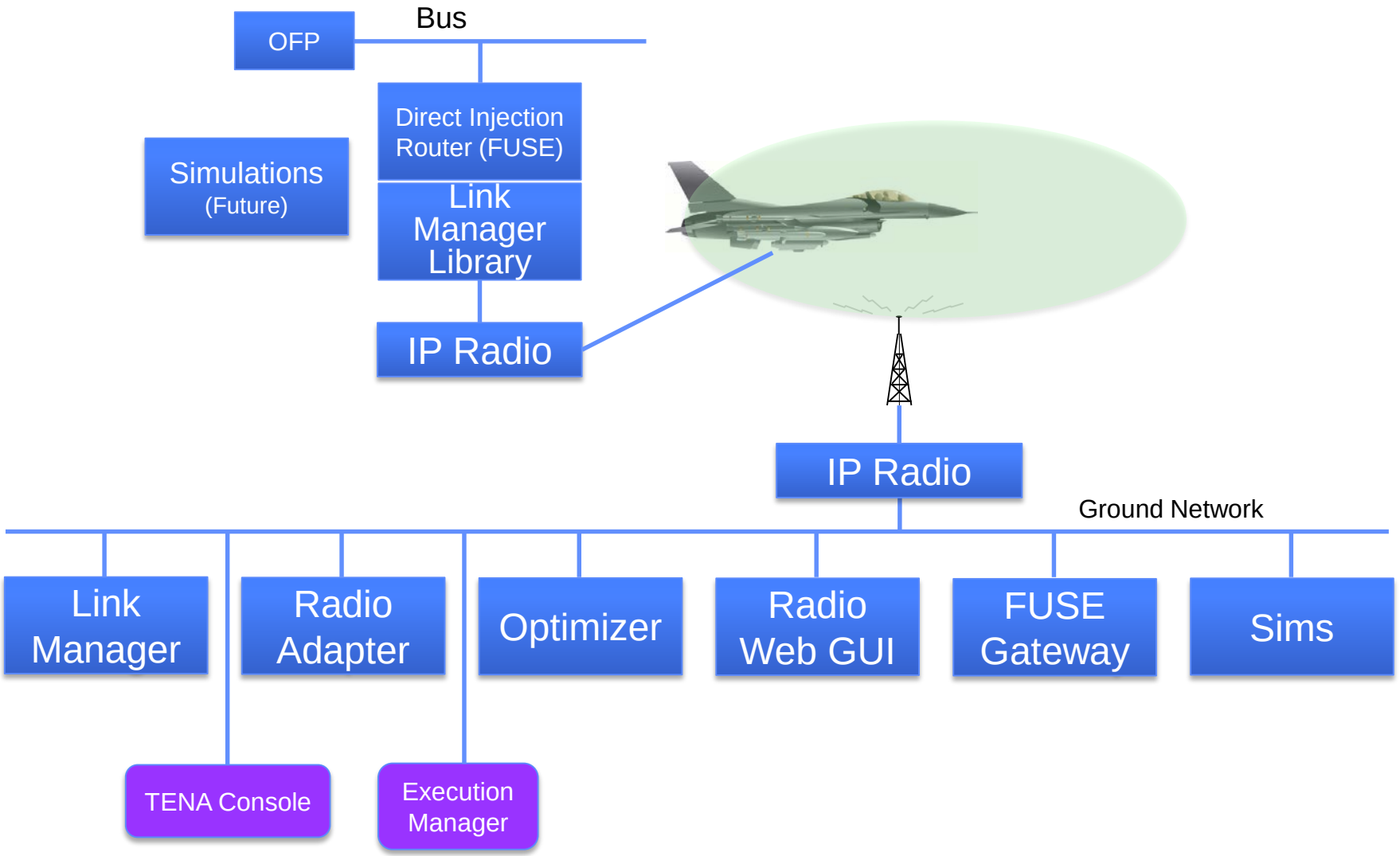
LVCT Program Overview

- **Sponsor:**
  - Test Resource Management Center (TRMC)
- **EA:**
  - Gil Torres, C4I & Software Intensive Systems Test (C4T), Test Technology Area (TTA)
- **Objectives:**
  - Integrate virtual and constructive simulations with live aircraft platforms, by creating technology prototypes and testing them in an operationally-relevant environment
  - Mature key LVC technologies from TRL 3 to TRL 6
  - Transition LVC technologies to the T&E community
- **Recent Accomplishments:**
  - Integrated constructive (ThreatIOS) and virtual (HQSim) simulations over the Emulated Air-to-Ground Network
  - Evaluated radio network performance over realistic flight conditions using the Emulated Air-to-Ground Network



LVCT ARCHITECTURE AND TECHNOLOGIES

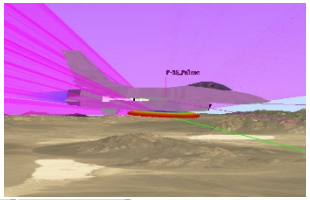
Block Diagram Architecture

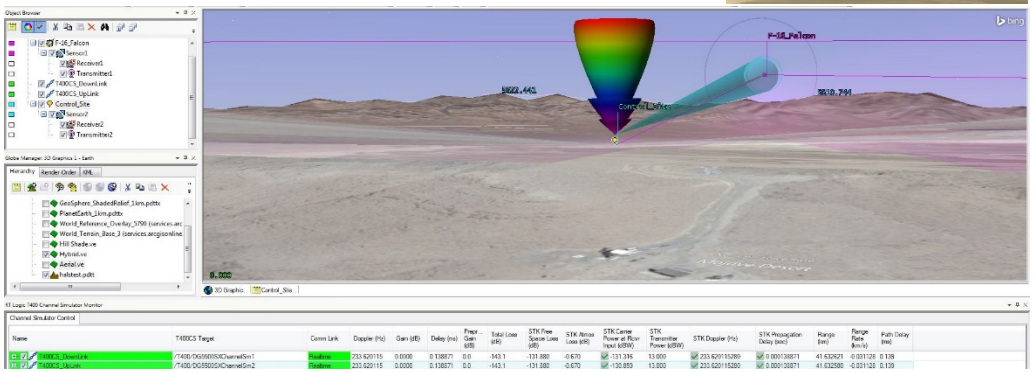


Range Assets Are Modelled and Visualized in the Emulated Air-to-Ground Network

Body Masking design

Antenna Pattern Design

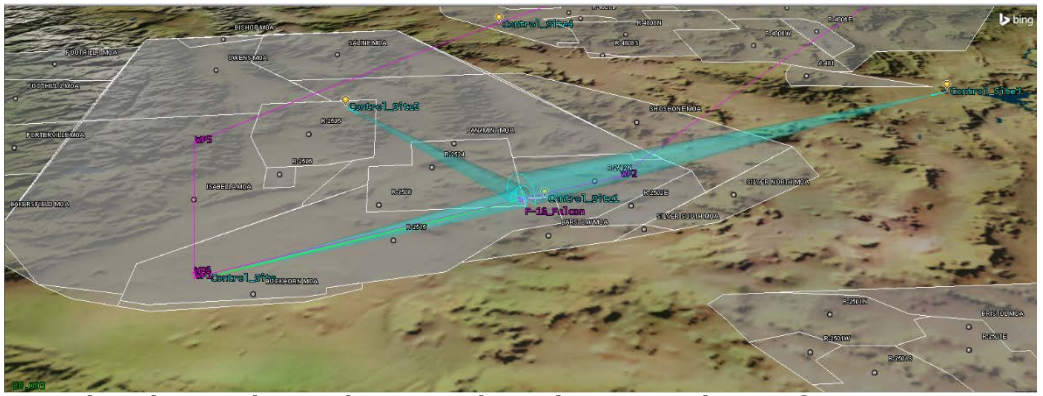




AGI STK Simulation /Channel Simulator Control

Parameters of Interest

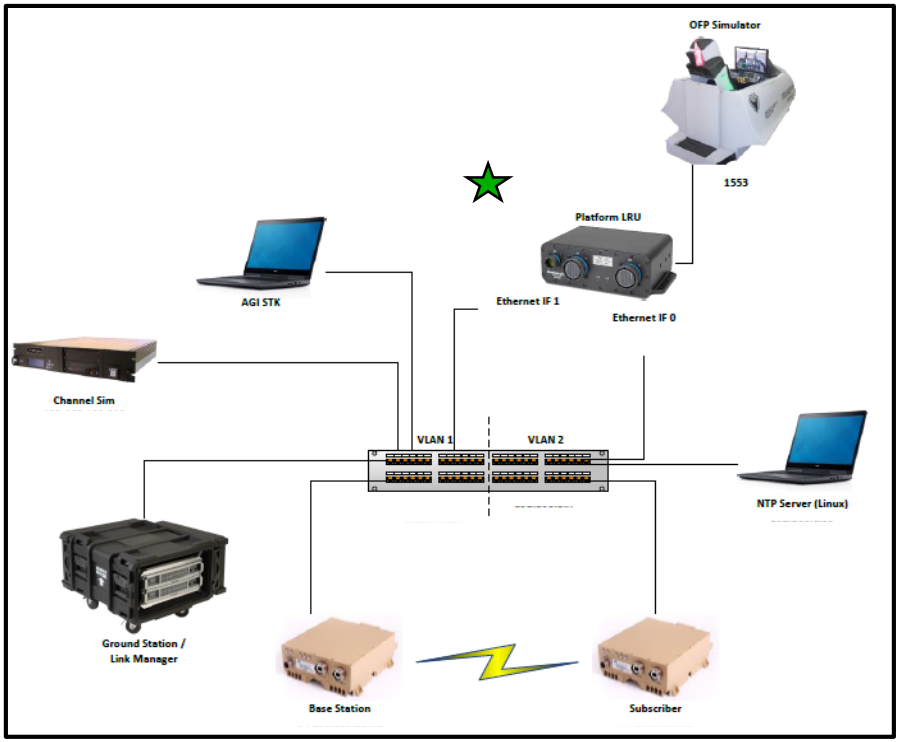
Manual or automatic control (STK)
Distributed Interactive Simulation
Up / Down converters
Doppler Shift
Path Loss/Fading
Delay
Noise
Phase Noise
Multipath – 4 channels
Programmable FIR Filters
Terrain effects
Atmospheric effects
Modulation / antenna effects



Site location determination and performance

Direct Injection Router Interfaces with the Aircraft 1553 Bus

Direct Message Injection – Creating Software Patterns that Support Mission System & Sensor Awareness of Simulated Data



- Provides an interface to a specific Bus Architecture (in this instance 1553)

Phase 1 Exit Criteria

Technology	Exit Criteria	Met/How
Emulated Air-To-Ground RF Network	• Demonstration that the LVCT test-bed has been created with an emulated air-to-ground RF network	By showing the Test environment and demonstrating an operational scenario.
Quality of Service (QOS) Algorithms	• Review of an object model representing the information necessary to execute the use case • Review and demonstration of the Quality of Service algorithms on the ground station have been created and tested in the above test-bed, including traffic shaping and prioritization	Object model reviewed previously. Use cases described in the Test Plan and executed with. Traffic prioritization provided through ENet or ZeroMQ library and shaping performed both through the link manager filtering as well as the optimizer for simulation traffic management.
Dynamic Radio Configuration Algorithms	Review and demonstration of: • the mission maps for spectrum usage and • the ability to adjust communications parameters during a test	Mission map consists of only two radios .. Parametric monitoring and change of values performed through GUI.
Direct Injection Router	• Stable under test based on test documentation with appropriate plug-in modules	Operation of scenarios demonstrating messages from the ground simulation to the aircraft. RADAR tracks, Weapon shots.. TSPI data.
Prototype LVCT Live Flight Test	• Letter of Introduction to Edwards • Interface plan with Edwards 412 Test Instrumentation Group • Completed Range Survey	Yet to be completed. Expected in July.

Demonstrated ability to meet specification parameters of: Radio Range (NM) per Hop (Using software defined radio (SDR) – Various waveforms), Number of Live Platforms Number of Synthetic Participants (Constructive or Virtual), Latency, OT Setup, Integration to Platform (Open Systems Architecture Approach), Radio Mission Map Configuration (Heterogeneous) [Power, Frequency, Modulation, etc.]

Potential Benefits of LVCT to T&E

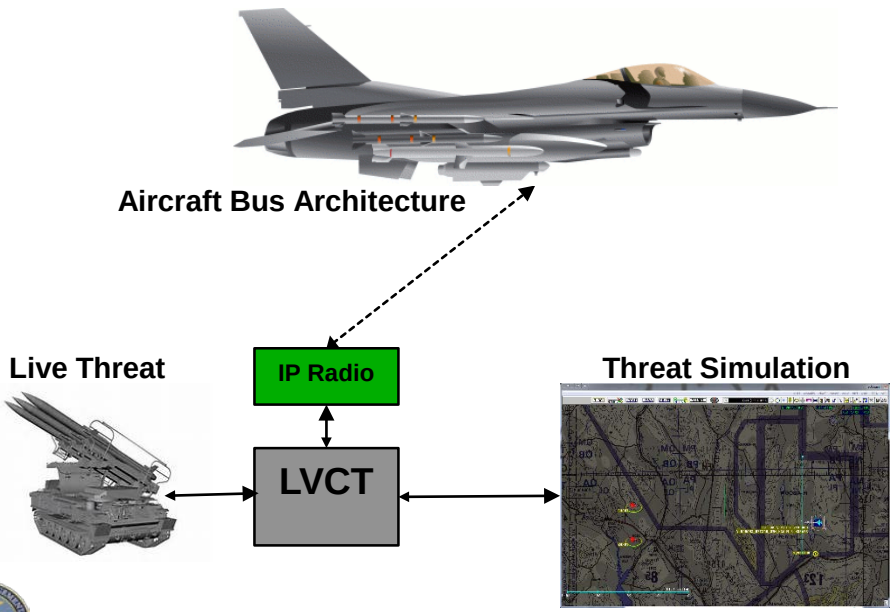
- **Question: How can I test system and subsystem performance in a live flight, contested but controlled environment?**
  - Inject Messages onto the aircraft's mission bus architecture to stimulate systems (Open Systems Architecture)
  - Stimulate the advanced platforms/5th Generation system into an environment with virtual and constructive simulated threats
  - Provide feedback for 5th Gen modifications required for LVC
  - Best utilize kinetic range airspace to stress platform performance across a variety of missions that is currently not feasible.

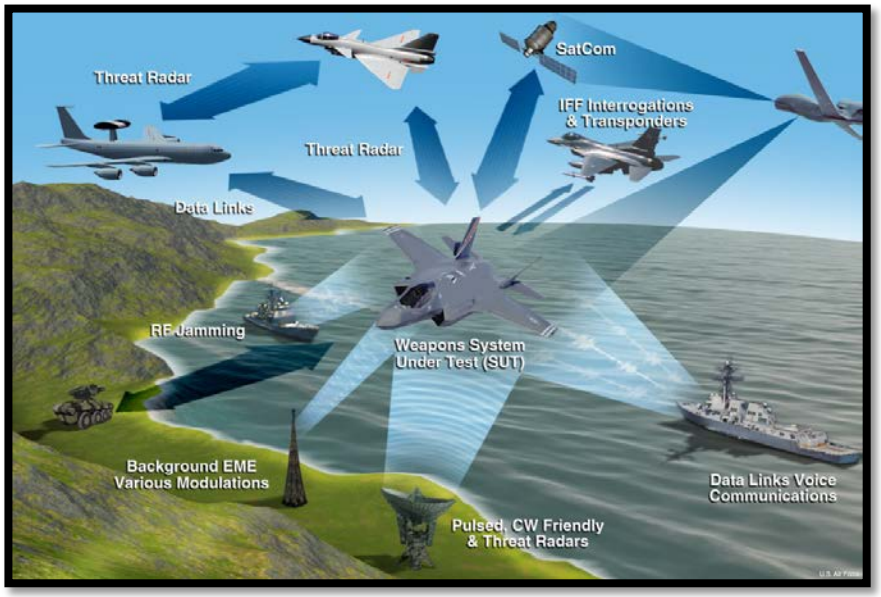
Potential Benefits of LVCT to T&E

- **Question: How can I perform operational testing on advanced/next gen platform full mission capabilities in a restricted live range environment?**
  - Simulate the entire mission space without the expense of fuel, crew, and equipment (Pick the best mix of live and synthetic systems)
  - Inject indicators that require an appropriate crew response
  - Develop Open Architectural changes to the Platform to Make OT/LVC Routine

Potential Benefits of LVCT to T&E

- **Electronic Warfare Operational Test – LVCT provides the facility to interface with the Mission System and Subsystems/Sensors on federated or Fused Architectures. By interfacing with the EWMS it is possible to drive both Range based and constructive threat data into the system to provide the appropriate Stimulus (Requires support from the OEM)**





Major Phase 2 Tasks

- **Extend the RF testbed to the LVC environment**
  - Integrate the RF Emulation Test-bed as a “test harness” into the full LVCT software-in-the-loop (SWIL) and HWIL environments for extended testing of the actual mission systems.
- **Refine the QoS algorithms developed in Phase I to incorporate lessons learned from testing**
  - Make enhancements to the Link Manager software and object models to incorporate additional QoS algorithms while taking into consideration any modifications required to the Dynamic Radio Configuration application.
- **Modify the Dynamic Radio Configuration behavior to ensure it can support the QoS algorithms**
  - Conduct HWIL testing and establish performance characteristics to ensure the prototype is addressing error and fault conditions satisfactorily.
- **Advance the development and test of the Direct Inject Router**
  - Enhance and extend the direct message injection router to meet mission and aircraft requirements.
- **Iterate multiple HWIL tests with Real Mission Systems**
  - Conduct multiple HWIL tests, allowing for time to adjust software and algorithms as appropriate.

Potential Enhancements

- **Continue to Develop the Data Link and Transition to the TENA – SDA**
- **Improve the performance and utility of the Radio Test Bed**
- **Further Develop Integration Methods for Aircraft**

Summary

- **LVCT** provides a framework and software components that will push the operational test of Live platforms in highly contested environments forward – the intent is to mix realities and advance capabilities in the operational test domain.

- **Technology innovation**
  - Advanced scalable Data Link that can perform under different spectral bands and across waveforms
  - Software patterns for open mission system integration to reduce cost to platforms and programs
  - A path to integration of 5th generation (fused information systems)

- **LVCT** through leveraging of other S&T projects as well as its own investigations will bring the network to Net-Centric Operational Test
  - Range Compatible Data and Waveform Integration
  - Open Systems Approaches to Integration
  - Mission Focused Systems Architecture