Live Virtual Constructive Technologies for Test (LVCT)

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33rd Annual International Test and Evaluation Symposium
Problem Statement

• 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 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)
Project Description

- LVCT is Developing Software & Communications Technologies to Permit LVC Operational Test for 4th and 5th Generation Aircraft.
  - Enable Mission System and Sensor Integration to Inject Threats/Targets and Listen to the Aircraft Buses for Real Time Monitoring & Management
- LVCT Provide Guidance on the Application of Waveform & Spectrum Use.
  - Identify Waveform Candidates and Methods for LVC Network Configuration/Control

“Leverage S&T Activities to Accelerate!”
S&T Background

• Secure, Optimized Wireless Distributed Connectivity
• Open Standards for cost efficiencies
• Mission System and Sensor Integration
• Quality of Service for realistic scenario representation
• Spectrum Management for Scalability of Full Mission Test
## Project Specifications

**NOTE:** Project in Early Stages – Current and Ultimate are Subject to Further Test

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Current Performance Level</th>
<th>Current Target</th>
<th>Ultimate Goal</th>
<th>Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>Nautical Miles</td>
<td>100 NM</td>
<td>&gt; 150 NM</td>
<td>40 NM</td>
</tr>
<tr>
<td>Number of Live Platforms</td>
<td>Quantity/Units</td>
<td>4</td>
<td>&gt; 30</td>
<td>1</td>
</tr>
<tr>
<td>Latency</td>
<td>500mS Each way</td>
<td>&lt; 250mS</td>
<td>&lt; 100mS</td>
<td>~ 500mS</td>
</tr>
<tr>
<td>OT Environment Setup</td>
<td>Days to Weeks</td>
<td>Hours/Days</td>
<td>Minutes/Hours</td>
<td>Not Assessed</td>
</tr>
<tr>
<td>Integration into Platform</td>
<td>Months to Years</td>
<td>Months</td>
<td>Weeks to Months</td>
<td>&gt; 1 Year</td>
</tr>
</tbody>
</table>
Select Candidate Radio and Waveform for Test with the Data Link (LVC Link Manager) to assess Performance, develop OMs to Support the Test Environment and Test Against the Target Platform OFP (F-16) Through Mission Bus Injection.
Current Phase 1 Results

- Leveraging Earlier Efforts and S&T Tech (TRCE RelayNode) to Design LVC Link Manager Prototype
- Conducting Investigations on QoS and Transport Technologies while Establishing Lab Test Environment
- Selected WIN-T Local Access Waveform (LAW) Gaussian Minimum Shift Keying (GMSK) as the 1st Candidate Waveform, Aeronix as the Radio Provider
- Considering Stretch Goal to Include CRIIS

![Diagram](image-url)

- **Existing Capabilities**
  - Experimental F-16 M6.2 OFP
  - TRCE QoS Enhancement
  - ACES Training System (ATS)
  - RF Emulation Capability

- **Leverage**
  - OFP modifications to further prototype the most effective methods of stimulating mission systems and sensors
  - ENet will further investigate the scalability and prioritization issues for operational test
  - Lessons learned from ATS demonstration to exploit software-defined radios on live platforms and at test ranges
  - RT Logic ChannelSIM for characterization of bandwidth, latency and RF loss to assess mission system performance. Extend configuration for generalized use in HWIL and SWIL mission environments

- **Phase 1 Capabilities**
  - Direct Injection Router
  - Mission Context QoS Algorithms
  - Dynamic Radio Configuration Algorithms
  - Emulated Air-To-Ground Network
### TRCE RelayNode Prototype

- **Leverage Prototype from TENA in Resource Constrained Environments (TRCE) Project**

#### Auto-generated application that supports a wide range of object models
- Can be deployed at strategic points geographically on the LAN/WAN
- Supports each device connection in separate thread
- Replicates TENA API as closely as possible

**RelayNode Optimized Protocol (RNOP) minimizes Platform update size**

<table>
<thead>
<tr>
<th>TENA Event Execution</th>
<th>SDO &amp; Message Processors</th>
<th>RNOP Wire Format</th>
<th>eNET</th>
<th>RNOP Wire Format</th>
<th>UDP</th>
<th>RNOP Wire Format</th>
<th>Serial</th>
</tr>
</thead>
<tbody>
<tr>
<td>RelayNode</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Tablets & Smartphones**

**Live Fly Aircraft**

**Embedded Computers**

**Acoustic Modem**

**Auto-generated application that supports a wide range of object models**

**Can be deployed at strategic points geographically on the LAN/WAN**

**Supports each device connection in separate thread**

**Replicates TENA API as closely as possible**

**RelayNode Optimized Protocol (RNOP) minimizes Platform update size**
TENA 1.0.0 RelayNode

Leverage Technologies for Netcentric Test Interoperability (TNTI) Project S&T Efforts

• Single Application Mode
  – Used for individual communication links that have constrained or unreliable links
  – RelayNode can tolerate some transient communication faults

• Multiple Execution Mode
  – Used to connect separate site executions with a common WAN execution
  – Allows sites to operate independently, but exchange certain data with other sites
LVC Link Manager

Leveraging source code from TRCE RelayNode prototype and TENA RelayNode 1.0.0 to build LVC Link Manager Prototype using TENA Middleware 6.0.5 (new release)

- Evaluate multiple transport layers
  - Data Distribution Service (DDS)
  - ZeroMQ
  - RabbitMQ
  - eNET
  - Session Description Protocol (SDP)
- Evaluate QoS Approaches
  - Partial Dynamic Updates
  - Geospatial Filtering
  - Reliable/Best Effort Channelization by Message Type / Instance
  - TENA Tag Filtering
RF Link Laboratory Testing

- RT Logic T400 RF Channel Simulator

Transmit Equipment
- Modems
- Radios
- Transmitters
- Firmware
- Software

Receive Equipment
- Modems
- Radios
- Receivers
- Firmware
- Software

IF/RF Cable

IF/RF Cable

Doppler Shift
Path Loss
Multipath Fading
Delay
Noise
Phase Offset
Interference
Visualization and Control

- Analytic Graphics System Tool Kit (AGI STK)
  - Provides equations to calculate the RF environment
  - Provides control of the T400CS hardware
  - Provides antenna selection, modification and characteristics
  - Provides visualization of flight paths
  - Allows Physics Complaint testing and analysis of RF systems
Several components were used to develop an RF Link Test System
- RF Channel Characteristics generation – RT Logic T400 Channel Simulator
- Command and Control Interface – Analytic Graphics System Tool Kit
- Visualization – Analytic Graphics System Tool Kit
- Candidate Transceiver – Aeronix Advanced Network Radio Transceiver
- UDP Data Test Generator – Iperf / Jperf
Half Duplex Modem, T400CS Channel Simulator Test Setup

Ground Station
ANR Base Station Transceiver
Tx = 2.412 GHz, 3 dbm, 2.412 GHz, Rx = -41 to -82 dbm

Aircraft to ground communications test
(one way IP traffic from subscriber to base station)

Aircraft
ANR Subscriber Station Transceiver
Tx = 2.412 GHz, 3 dbm,
2.412 GHz, Rx = -41 to -82 dbm

Splitter

Splitters have 3dB drop

Attenuator 1
(Translate to T400CS Power Constraint of -26 dbm), 20 db

Channel 1 & 2 output variable
-38 dbm to -78 dbm

Attenuator 2
(Translate to T400CS Power Constraint of -26 dbm), 20 db

RT LOGIC T400CS

Down Converter
2.412 GHz -> 70 MHz IF, 8 db internal pad

Up Converter
70 MHz IF -> 2.412 GHz, 10 db internal pad

Up Converter
70 MHz IF -> 2.412 GHz, 10 db internal pad

Down Converter
2.412 GHz -> 70 MHz IF, 8 db internal pad

Channel 2 (DGXX00)

Channel 1 & 2 output variable
-28 dbm to -68 dbm

Channel 1 (DGXX00)

-28 dbm
TENA Adapter Framework for Dynamic Control of Ground Station Radios

Leverage Technologies for Netcentric Test Interoperability (TNTI) Project S&T Efforts

Architecture/framework attempts to separate adapter specific code into the four areas shown:

- **Legacy System**
- **Legacy Communication I/O**
- **Protocol Conversion**
- **Remote GUI Control (future)***
Next Phase Outline

• **Technology**
  – Further Develop Relay Node & OMs
  – Create Radio Configuration Software – Test Operator Station (TOS)

• **Development**
  – Test Against Other Waveforms
  – Test in Relevant Environment

• **Prototype for demonstration testing**
  – Scenario Creation - LVC
  – Use Case Test Development

• **Documentation**
  – Requirements and Test Results
## Project Transition Plan

<table>
<thead>
<tr>
<th>Test Activity (e.g. AFRL (KHILS/GWEF) or CTEIP Activity (e.g. DETEC))</th>
<th>Need Quarter/FY</th>
<th>Level of Coordination</th>
<th>Intent to Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFRL Secure LVC Advanced Technology Environment (SLATE)</td>
<td>Q4 2018</td>
<td>Coordination with the Technical Lead Dr. Winston Bennett 711 HPE</td>
<td>Backup to LVC Waveform &amp; Compressed DIS Data Link</td>
</tr>
<tr>
<td>TENA Software Development Activity (SDA)</td>
<td>Q4 2018</td>
<td>Coordination with Mr. Ryan Norman (TENA-SDA)</td>
<td>LVC Link Manager to compliment TENA Relay Node for Wireless LVC connectivity</td>
</tr>
</tbody>
</table>

### Benefit to Warfighting
- Provides the Ability to conduct complex Operational Tests in Complex Environments with 4th and 5th Generation Assets – Compatible with Existing Range Infrastructure
- Provides requirements that will Transition LVC fro Vague to Specific for Mission Systems and Sensors (Reduce Overall Modification Cost Early)
Partnerships and Roles

- **Government Executing Agent:**
  - Mr. Gil Torres

- **Principal Investigator:**
  - Mr. Mark Phillips

- **Subcontractors:**
  - Leidos

- **Potential Collaborators**
  - CRIIS Program
  - International Partners
  - Aeronix
  - Rockwell Collins
  - 412 Test SQN
  - USAF Test Pilot School
  - AFRL
  - TENA-SDA
  - NAVAIR Atlantic Test Range (ATR)
FY16/17 Schedule

We Are Here
Wrap Up

• LVCT (LVC for Operational Test) 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
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