



Test & Evaluation (T&E)/Science & Technology (S&T) Program

New Simulation Techniques for Warfighter Systems T&E

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October 4, 2017



C4I & Software Intensive Systems Test (C4T) Mission



Mission

Develops technologies to test C4I and Software Intensive Systems that operate in complex military environments. With emphasis on automated testing, analysis (real-time and post-test) and evaluating the increasing mass of structured and unstructured data. C4T is divided into the following three domains:

1. Distributed Testing: This domain will address technologies to: reduce T&E infrastructure biases, improve T&E cross domain/multi-level security abilities, advance T&E for platforms employing big data/cloud environments, and create agile/contested/dense communication environments.
2. Test Automation: This domain will address technologies to: advance Test Big Data Collection, Analysis, Reporting, & Visualization; create high fidelity representations of operational systems or net-centric environments; and assess next generation of warfighter managed information objects.
3. Modeling & Simulation: This domain will address technologies to: determine required fidelity in Live and Simulated environments; improve the Validation & Verification and Aggregation techniques; improve run-time performance for real-time applications, and systems, communications, and environmental representations.





C4I & Software Intensive Systems (C4T) Overview Technology Domains



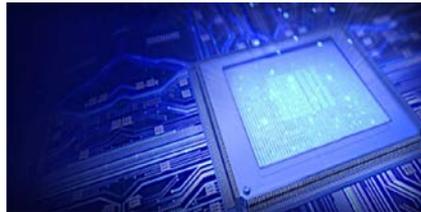
Complex Warfare Environments

Innovative approaches to how we fight, posture our force, & leverage our asymmetric strengths & technological advantages*



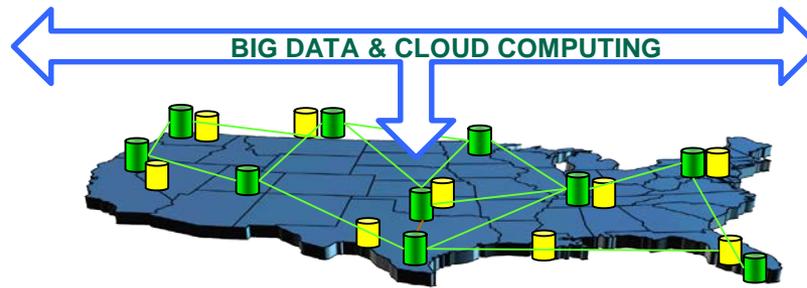
Battle increasingly sophisticated adversaries in increasingly complex environments*

* 2014 Quadrennial Defense Review



Test Automation (TA)

- T&E Big Data Rapid Analysis
- Automated Testing Utilizing Virtualization and Cloud Environments
- NextGen Handhelds and Widgets
- Automated Control of Targets



Distributed Testing (DT)

- Remove Test Infrastructure Biases
- Cross Domain Solutions and Multi-Level Security
- Assess Big Data Warfighter Systems
- Testing Warfighter Systems Employing Agile Comms
- Emulate Contested/Dense Communications Environments



Modeling & Simulation (M&S)

- Determine Simulation Fidelity
- V&V Across Battlespace Environments
- Battlespace Environments Aggregation
- Improve Simulation Run-time Performance
- Representation of Systems, Communications, and Environments

Innovate T&E: Joint, Early, Often & Agile

Distribution Statement A





Topics For Discussion



- **An Overview of Simulation Reqs for OT/DT Test Environments**
- **The M&S Test Environment**
- **The LVCT Environment**
- **V&V Techniques**
- **Summary**





Requirements for Consideration in Creating the M&S Test Environment



- **Fidelity: The simulated test environment must have adequate fidelity to both stimulate and stress the System Under Test (SUT).**
 - Stimulation must consider the primary, and in most cases secondary interactions of the SUT with the environment
 - The under sea/surface environment must consider all objects that reverberate the sonar pulse.
 - To effectively provide an OT environment, the simulation must provide those extreme cases that stress the SUT
 - The environment must overload the sensors to determine “edge performance” of the SUT
 - While “aggregations” in the simulated test environment are possible, care must be taken to assure that their impact on the SUT is correctly represented
- **Timing: The simulated test environment must update at a rate less than the operational update rate of the SUT**
 - Clearly the simulated environment must run in real-time but the requirement for it to update “within the cycle of the SUT” may require that some parts run faster than real-time.
 - There is often a “tradeoff” between environment fidelity and timing (update rate).





Torpedo Operational Test Using Modeling and Simulation (TOTUMS)

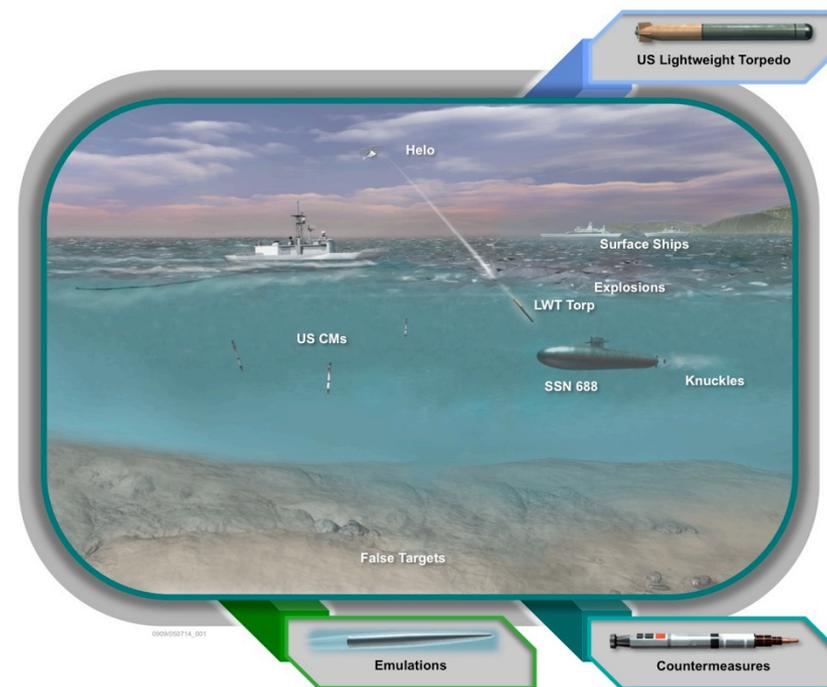
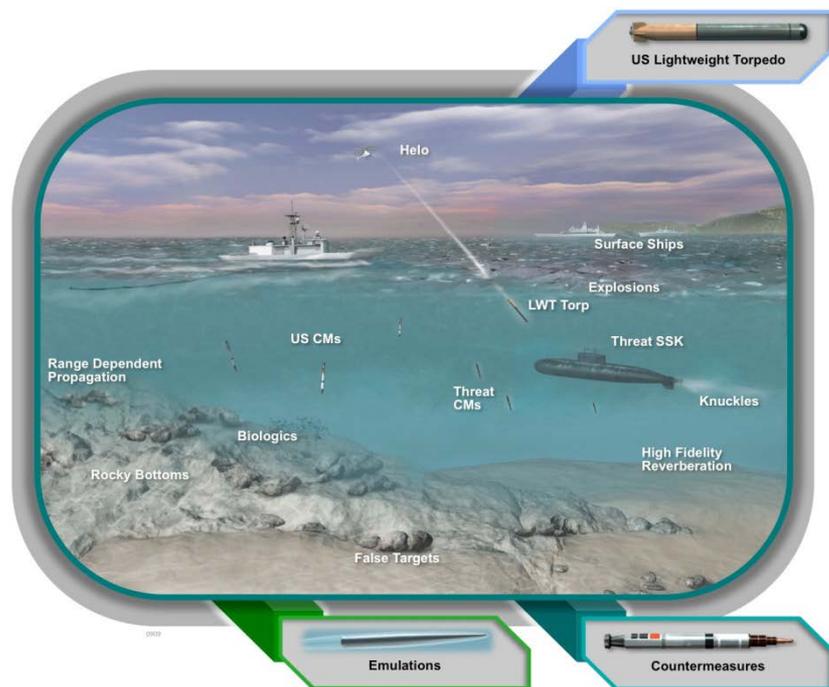


- **Provide diverse real world test environments not possible within the constraints of in-water Operational Test through the use of accredited Modeling and Simulation (M&S) that will allow Commander Operational Test & Evaluation Force (COMOPTEVFOR) to fully evaluate torpedo Anti-Submarine Warfare (ASW) performance attributes**
 - **New environment centric framework allowing for multiple hardware-in-the-loop (HWIL) entities**
 - **Range dependent propagation environments representative of waters anywhere in the world**
 - **Threat representative targets, CMs, tactics**
 - **Threat representative high clutter environments dominated by false alarms / targets (biologics, wakes, knuckles, explosions)**
 - **Enhanced testing realism by simulating actual engagement scenarios (end-to-end with no peacetime safety rules)**
 - **Testing of multiple weapons in a simultaneous attack**





Test Concept with TOTUMS



Enhanced WAF Simulation
Providing more realistic and challenging test engagement environments to supplement OT

Continue with Established In-water OT testing





Fast Gaussian Ray Bundle (FAST GRaB)



Naval Underwater Warfare Center / Newport , RI



Description: Development of technologies enabling the range dependent propagation in real-time, quantification of the fidelity of M&S environment, prediction of torpedo effectiveness and target autonomous evasion.

Enables: Optimized fidelity & statistical confidence level for a M&S environment to support Operational Testing of torpedoes and autonomous evasion for a target in the simulation. Additionally provided new and fast propagation model.

Current Status: Transitioned capability to quantify fidelity of a complex simulation as well as estimating Teff.

Integrated target autonomous evasion into WAF capability
Transition Partner/Date: NUWC EC WAF, NAVSEA PMS 404 / 4QFY17

FY17 Accomplishments:

- ✓ Ranked the performance of 66 in-water Heavyweight Torpedo (HWT) runs using the ECF
- ✓ Ranked the performance of 752 WAF Lightweight Torpedo (LWT) torpedo runs
- ✓ Demonstrated Evasion engine at program review
- ✓ Develop and Demo Evasion Cost Function EvCF

Deliverables:

- ✓ Transitioned WARP (Apr/15) and ECF and related applications
- ✓ Provided briefs and demonstrations for C4T end of program review (Evasion task)
- Final Report

Key Future Events:

- Meet with PMS 404 to discuss use of ECF as the measure of torpedo performance
- Complete Autonomous Evasion Task transition to EC-WAF



The Live, Virtual, Constructive (LVC) Environment for T&E



For an LVC environment, the system is tested, with “Users in the Loop” presenting the Simulated Environment with new problems.

- **Breadth/Fidelity of the Simulated Environment.** The LVC simulations must focus on stimulating both the SUT and the live actors (often a user) in the test environment.
- **Impacts of the LVC Infrastructure.** In cases of LVC testing, pieces of the test simulated environment are often distributed by WAN or RF communications.
 - Simulation of enemy aircraft facing a pilot in flight may be on the test aircraft or the ground station communicating with the test aircraft. Problems include:
 - Latency of the communications structure stimulating the SUT
 - Bandwidth of the communications structure stimulating the SUT
 - TENA 6.2 is useful in creating a distributed LVC infrastructure and explicitly addresses the latency/bandwidth problems

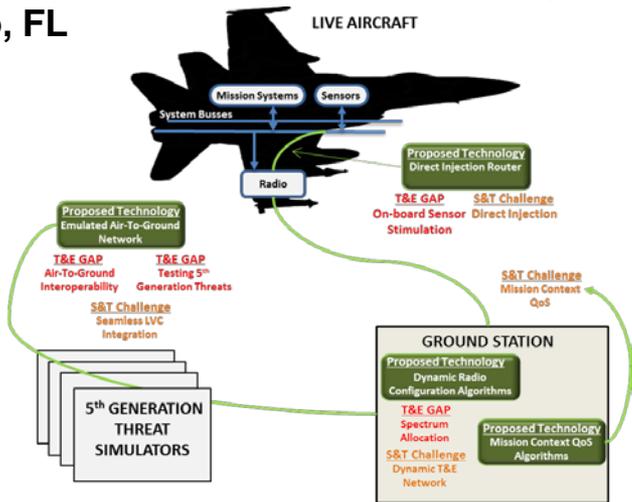




Technologies for Interoperability of Live Platforms with Virtual & Constructive Simulation for Distributed Test (LVCT)



Lockheed Martin Rotary and Mission Systems / Orlando, FL



Description: Develop technologies to provide a reliable, fast, and cost-effective approach that enables Live Virtual Constructive (LVC) testing of next generation air platforms through a set of reusable and reconfigurable technologies.

Enables: Live assets to sense and respond to stimulus without regard for whether the stimulus is real or synthetic in a realistic operational scenario

Current Status: Extending RF Test Bed to the LVC Environment. Enhancing Direct Injection Router, Dynamic Radio Configuration, and Quality of Service (QoS) applications and algorithms developed in Phase 1..

Transition Partners / Date – Eglin AFB, Edwards AFB, PAX ATR / 2QFY19, TENA-SDA

FY17 Accomplishments:

- ✓ Completed Quality of Service (QoS) Algorithms, Object Model development, LVC Link Manager (LLM) and Direct Injection Router applications
- ✓ Finalized Emulated Air to Ground RF Network
- ✓ Complete Range Survey and Modeling
- ✓ Phase 1 Decision Meeting and Demonstration / SWIL and HWIL Tests at Handling Qualities Simulator (HQSIM) at LM Fort Worth

Deliverables (Mo/Yr):

- ✓ LVCT Emulated RF Network User's Guide
- ✓ Final Technical Report
- ☐ All developed software

Key Future Events:

- ☐ Presentation to Range Commander's Council (RCC)
- ☐ SIL Tests at Handling Qualities Simulator (HQSIM) at LM Fort Worth



Verification and Validation of a Complex M&S Environment for T&E of a System Under Test (SUT)



- V&V of the Test Environment must establish the adequacy of the fidelity/time regime of individual simulations and the adequacy of the fidelity/time regime of the entire federated environment to stimulate the SUT.
- V&V of this M&S Test Environment must establish the environment's robust ability to stimulate the SUT across its full spectrum of performance requirements.
- The resulting Test Environment must create a Data Chain With Causality (DCWC) that can be tracked from changes in the M&S environment to changes in SUT performance. The DCWC must be validated.





Validation of an M&S Environment for T&E (Representations and V&V)

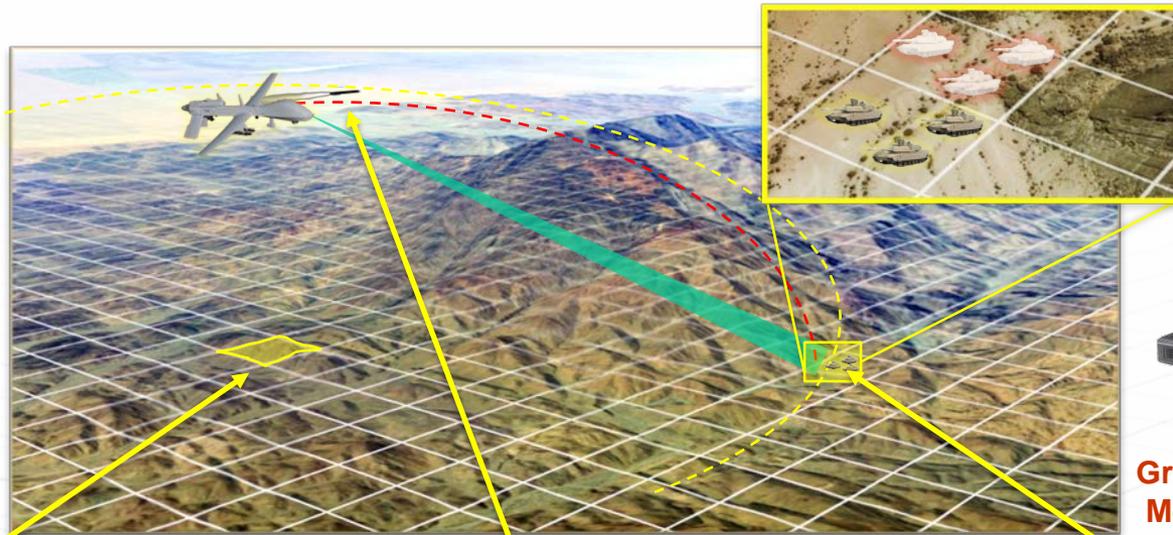


Simulated Test Environment of Battlefield Robustness

**Sensor Platform/
Aircraft Movement
Simulation**
Update Rate (200 msec)



Terrain Generator
100 Meters Per Grid Tile



**Rocket Sensor Guidance Software
System Under Test (SUT)**



**Rocket Fly Out
Simulation**
Update Rate (100 msec)
Non-Continuous



**Ground Target/Vehicle
Movement Simulation**
Update Rate (1 sec)
Non-Continuous



Sensor Update Rate (50 msec); Guidance Update Rate (100 msec); Accuracy \approx 6m (CEP)





Summary



- **Simulation Environments creating DT/OT situations for SUT testing are a reality. The requirements for creating these environments include:**
 - High fidelity, real-time simulations to stimulate the SUT
 - Simulations with a robust range of capabilities (i.e. to generate a spectrum of outputs) to test overall SUT performance
 - Simulations that have an update rate cycle within the update cycle of the SUT.
- **Verification and Validation of M&S Environments for DT/OT are Complex. Requirements include :**
 - Validation of the individual simulations in the environment AND validation across the environment of all simulations impacting the SUT
 - Verification and Validation and testing of the existence of the Data Chain With Causality (DCWC) of impacts on the SUT

