ITEA 35th Annual International T&E Symposium

The DoD T&E/S&T Program

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Test Resource Management Center
Test & Evaluation / Science & Technology Program
(TRMC, T&E/S&T)
The STEWARD of the DoD Test Infrastructure
Major Range and Test Facility Base (MRTFB): The “Critical Core”
23 Sites: Army-8; Navy-6; Air Force-7; Defense Agency-2

Legend:
Army, Navy, AF, Defense Agency
The TRMC “Blueprint”

Defense Strategic Guidance
(National Defense Strategy)

S&T Investments (COI) → Acquisition Process → Service T&E Needs and Solutions Process

Annual T&E Budget Certification

Strategic Plan for DoD T&E Resources

MRTFB Oversight

TRMC Investments Aligned to the National Defense Strategy

- Risk mitigation needs
- Technology shortfalls

Service Modernization and Improvement Programs

Acquisition Programs and Advanced Concept Technology Demonstrations

T&E Multi-Service/Agency Capabilities

DoD Enterprise Distributed Test Capability

TRMC Joint Investment Programs

(BA3 Funding)

Risk mitigation solutions
Test Technologies

(BA6 Funding)

Requirements → Capabilities

(BA6 Funding)

Requirements → Capabilities

(BA6 Funding)
DoD S&T Reliance
Communities of Interest

Mission Focus
Capabilities enabled by advanced technologies and systems

Systems / Capability Focus
Multiple technologies are integrated into complex systems to achieve mission impact

Technology Focus
Technology goals with multiple applications

S&T Investments are Best Leading Indicator of Future DoD T&E Needs
USD(R&E) Technology Priorities

Building Joint Lethality

• Hypersonics – Offense and Defense
• Directed Energy
• Fully Networked Command, Control & Communications
• Space Offense and Defense
• Cybersecurity – Offense and Defense
• Machine Learning (Artificial Intelligence)
• Autonomy
• Quantum Science (Including Encryption and Computing)
• Microelectronics
Mission: Develop Technologies Required to Test Future Warfighting Capabilities

- Established in FY02
  - Joint DDR&E / DOT&E Initiative
  - Transitioned to TRMC in FY05
- RDT&E Budget Activity 3 funds
- Purpose
  - High Risk / High Payoff R&D for Testing
  - Foster technology transition to major DoD test ranges
  - Risk reduction for test capabilities developments

- Broad Agency Announcements (BAAs)
  - Academia
  - Industry
  - Government Laboratories
- Tri-Service working groups
  - Validate requirements
  - Evaluate proposals
  - Facilitate technology transition
- Central Management – Distributed Execution

Eight Test Technology Areas

- High Speed Systems
- Autonomy and Artificial Intelligence
- Spectrum Efficiency
- Advanced Instrumentation
- Directed Energy
- Cyberspace
- Electronic Warfare
- C4I & Software Intensive Systems

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Shaping Technology into Tomorrow’s T&E Capabilities
T&E/S&T Program
Overview

• Develop technologies required to test future warfighting capabilities

• Designed to support DoD advances in warfighting technology
  o Align to National Defense Strategy and USD(R&E) technology priorities
  o Respond to S&T Drivers (Emerging technologies in DARPA & Service S&T)
  o Reduce Test Capability Development Risk (for CTEIP and Service I&M)
  o Leverage S&T Developments for Testing

• Core T&E/S&T Tenets
  o Must address T&E Need
  o Must advance/mature technology (TRL-3 through TRL-6)
  o High risk / high payoff investments
  o Transition strategy to relevant stakeholders
Test Technology Investment Prioritization Drivers

• **Warfighter Capabilities**
  - Improve Lethality
    - Hypersonics
    - Cyber / Electronic Warfare
    - Directed Energy
    - Autonomous Systems
  - Improve Resilience
    - Cyber / Electronic Warfare
  - Improve Interoperability
    - System of Systems
    - Mission-Level Effectiveness

• **Acquisition Programs**
  - Reduce the Cost of Testing
  - Improve the Quality of Testing

• **T&E Needs**
  - Optimize Spectrum Usage
  - Mitigate Range Encroachment
  - Improve the T&E Workforce

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**Test Technology Areas**

- **High Speed Systems Test**
- **Cyberspace Test**
- **Electronic Warfare Test**
- **Directed Energy Test**
- **Autonomy and Artificial Intelligence Test**
- **C4I & Software Intensive Systems Test**
- **Spectrum Efficiency Technology**
- **Advanced Instrumentation Sys Technology**
High Speed Systems Test
Domains

Ground Test
Improving Propulsion Ground Test Methods, Expanding Test Envelopes, Improving Accuracy & Fidelity, Reducing Uncertainty, Combined Aero Effects on Sensor/Seeker

Computational Tools
Advancing Modeling & Simulation (M&S) Capabilities for Hypersonic T&E

Instrumentation
Innovative New Sensors, Improving Accuracy, Increasing Measurement Ranges

Weapon Systems
Scramjet Vehicles
Boost Glide Vehicles
Re-entry Vehicles
Railguns
Interceptors
Turbine Engines

Flight Test
Improving Mission Assurance and Launch Flexibility, Developing In-Flight Measurements, Increasing Data Capture per Flight

Improved Aeroheating & Ablation Test Capabilities, Improved Flow Quality, High Speed / Hypersonic Systems (HS/H) Munitions Dispensing Testing
Hypersonic Cruise Missile
T&E Shortfalls

**Boost Phase**
- Ignition Testing
- Transonic/Supersonic testing of system
- Booster separation wind tunnel testing

**Scramjet Ignition**
- Inlet performance and operability testing
- Propulsion system
- Ignition testing
- Fuel schedule for start

**Scramjet Powered Flight**
- Isolator/Combustor development
- Isolator margin
- Propulsion system
- Combustion stability
- Performance and operability
- Accurate flight conditions
- Fuel schedule optimization (max range)
- Heat exchanger performance

**Air Launch**
- Store separation testing
- Combined system aerodynamic testing
- Stability, control effectiveness

**Captive Carry**
- Booster testing
- Wind tunnel testing of assembled stack

**Sensor Characterization**
- Calibrate sensor and fly the mission with hardware in the loop testing

**Terminal Dive**
- Guidance & navigation
- Validate Stability and Control predictions
- Lethality
- Lift and drag testing
- Aerothermal structural response

Notional Mission
**Boost-Glide Vehicles**
**T&E Shortfalls**

**Stage Separation**
- Verify clean vehicle separation, characterize staging effect on vehicle stability

**Booster Aero Stability**
- Validate Stability and Control (S&C) predictions for Booster Aero Stability for booster during ascent

**Surface Launch**
- Verify propulsion system performance, operability, and durability at flight conditions

**Leading Edge Thermo Structural Performance**
- Verify leading edge and Thermal Protection System (TPS) survival without damage or significant shape change

**Vehicle Aero Stability**
- Validate Stability and Control (S&C) predictions for flight vehicle maneuver and control

**Sensor Characterization**
- Calibrate sensor and fly the mission with hardware in the loop testing

**Weapon Deployment**
- Weapons separation from vehicle
- Sub-munitions impact

**End-Game**
- Vehicle condition during final dive and impact
- Vehicle signature
- Weather effects
- Aerothermal structural response
- Lethality

**Notional Mission**

[Diagram showing various stages and conditions of a boost-glide vehicle mission, including launch, stages of flight, and end-game scenarios.]
Directed Energy Weapons, organized in HEL or HPM domains, use the electromagnetic spectrum (light & radio energy) to attack targets at the speed of light.

**High Power Microwave (HPM)**
Produce wide beams in bursts of high frequency radio energy that disable or damage electronics.

**High Energy Laser (HEL)**
Produce coherent, powerful, monochromatic, focused light beams that heat the target body.

**C-IED HPM Systems**
**Threat Sources**

**Laser Area Defense Systems**
(SSL-TM/HEL MD)

**Joint High Power Solid-State Laser (JHPSSL)**
## HEL Mission Scenarios

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<tr>
<th>Propagation Medium</th>
<th>Target Platform</th>
<th>Target Effects</th>
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<tbody>
<tr>
<td>Self-Defense</td>
<td>Area Defense</td>
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<td>Aircraft</td>
<td>Aircraft Vulnerability</td>
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Electronic Warfare Test (EWT), organized into EO and RF domains, operates across the electromagnetic spectrum to improve Electronic Attack (EA), Electronic Protection (EP), and Electronic Support (ES) test technologies and capabilities.

**Electro-Optical (EO)**
- Missile Warning Sensor (MWS)
- Infrared Countermeasure (IRCM)
- Precision-Guided Munitions (PGM) EO/IR/UV seekers
- EO/IR Intelligence, Surveillance, and Reconnaissance (ISR) sensors on airborne platforms

**Radio Frequency (RF)**
- Radars and communications
- Radar Warning Receivers (RWRs)
- Electromagnetic sensors
- Jamming systems
- RF seekers on PGMs and RF ISR sensors on airborne platforms
- Integrated air defense system (IADS)
Cyberspace Test Technology Domains

- Develop advanced technologies and methodologies to test and evaluate DoD capabilities and information networks to defend and conduct full-spectrum military operations across cyberspace

- Three Domains of CTT

  1. **Cyber-Physical Systems**: Kinetic systems, cyber-physical networks, embedded systems - computer systems with a dedicated function within a larger mechanical or electrical system, often with real-time computing constraints

  2. **Tactical Edge Networks**: Information systems & connectivity supporting tactical edge communications and distributed operations – includes line-of-sight and beyond-line-of-sight data links, and other networked systems in the battlespace

  3. **Enterprise Information Systems**: Broad scope of unified communications and integration of telecommunications, computers, necessary enterprise software, middleware, storage, and audio-visual systems which enable users to access, store, transmit, and manipulate information
Cyber Range Vision

Current Asset/Facility Expanding Capacity to Meet Demand

Integrated Tool Suite & Automation Maximizes Utilization of Range Resources

Hi-fidelity Virtualized Representations of Networks, Platforms, C2, etc.

Step 1: Assign required range resources

Step 2: Pull automated components from the library or generate as needed

Step 3: Build out the Environment

Step 4: Ensure all components were deployed correctly

Step 5: Configure and deploy customized traffic generation and instrumentation packages

Step 6: Execution based on the event specific requirements

Step 7: Sanitize and return all exposed assets back into the resource pool for reuse

SME Available for Planning, Design, Execution, OPFOR and Analysis
Better Testing of Autonomous Systems leads to greater Warfighter Trust in their mission performance
C4I & Software Intensive Systems Test Domains

Complex Warfare Environments

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

Battle increasingly sophisticated adversaries in increasingly complex environments*

* 2014 Quadrennial Defense Review

Test Automation (TA)
- Advance Big Data Collection, Analysis & Visualization
- Improve Test Execution thru Automation/Cloud Computing
- Advance Testing for Next Generation of Handhelds
- Improve Automated Control of Targets

Distributed Testing (DT)
- Reduce Distributed T&E Effects
- Improve Security Posture of Systems
- Advance Mission Context Data Collection
- Analysis & Visualization

BIG DATA & CLOUD COMPUTING

Modeling & Simulation (M&S)
- Required Fidelity in Live and Simulated Environments
- V&V Techniques
- Aggregation Techniques
- Run-time Performance for RT Applications
- Systems, Communications, Environmental Representations

Innovate T&E: Early, Often, and Agile
Revolutionize the RF test range environment by leveraging network & cellular based technologies to support real-time wireless data communications.
Encroachment to DoD Testing
Spectrum Availability

- Increased complexity of weapon systems coupled with decreased availability of telemetry spectrum limits testing at national ranges (complexity of tests, data downlinks)
  - Available spectrum will be further reduced by potential loss of 1780-1850 MHz and sharing spectrum with commercial users
- Large amounts of data collected onboard system and analyzed post-test
- Continued investment in advanced RF and network technologies can partially mitigate the loss of spectrum
  - Advanced modulation schemes
  - Networked telemetry
  - Non-traditional portions of the RF spectrum (e.g. C-band, Ka/Ku-Band)

Increased Weapon System Complexity and Reductions in Available RF Spectrum Limit the Amount and Types of T&E Missions a Range can support
Adv. Instrumentation Sys. Technology Domains

**TSP1**
High accuracy and continuous TSP1 for high speed/high dynamic and GPS-degraded environments

**Advanced Sensors**
Enhanced performance sensors that meet emergent T&E needs

**Human Performance Measurement & Assessment**
Technologies to assess the human-machine interface, including improved methods to measure warfighter cognitive & physical workload

**Advanced Energy & Power**
Improved energy/power density systems for T&E

**Range Environmental Encroachment**
Technologies to mitigate impacts of environmental policies on test range operations

**Non-Intrusive Instrumentation**
Advanced data acquisition and processing components designed to be embedded within the system under test
T&E/S&T Program Summary

• T&E/S&T Program initiated to address critical T&E needs tied to S&T drivers
  – Advancing the state of the art in T&E technologies

• The only DoD S&T program dedicated to T&E

• Aligned and balanced to address the highest priority test technology needs in support of the National Defense Strategy

Looking Ahead, Relevant, Agile, and Efficient
Questions?

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