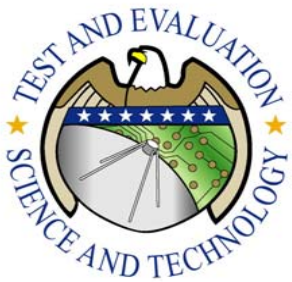




# The DoD T&E / S&T Program

**Gerry Christeson**

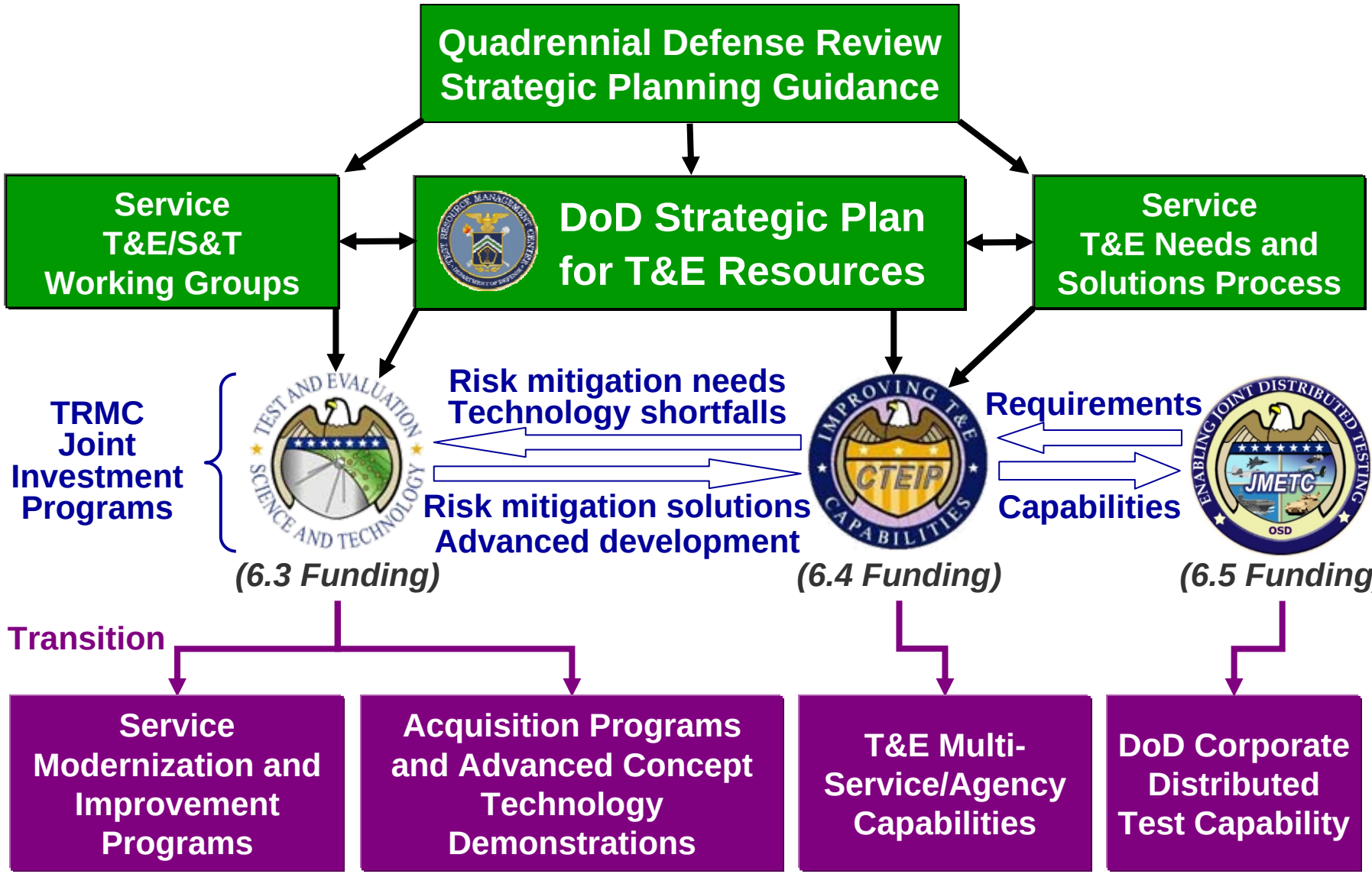
**Defense Test Resource Management Center**
**Test & Evaluation / Science & Technology Program**
**(TRMC, T&E/S&T)**

**NDIA 10TH Annual Science & Engineering Technology Conference**

# Test Resource Management Center (TRMC)

- **DoD Field Activity**
  - **Established to ensure that the DoD T&E infrastructure is adequate to support the development and acquisition of defense systems**
  - **Led by Dr. John Foulkes, SES**
    - **Direct report to the Under Secretary of Defense (Acquisition Technology and Logistics) and Director, Defense Research and Engineering (DDR&E)**
- **Annually certify that the T&E budgets of the military departments and defense agencies are adequate**
- **Develop a biennial DoD Strategic Plan for T&E Resources**
  - **Assesses T&E requirements for a period of ten years**
  - **Identifies required T&E infrastructure investments**
- **Responsible for all T&E infrastructure policy for the DoD's Major Range and Test Facility Base (MRTFB)**
- **Manage OSD funded T&E investment programs:**
  - **Joint Mission Environment Test Capability Program (JMETC)**
  - **Central Test and Evaluation Investment Program (CTEIP)**
  - **Test and Evaluation/Science and Technology (T&E/S&T) Program**

# Synergy through Aligned Investment



# T&E/S&T Program
## Overview

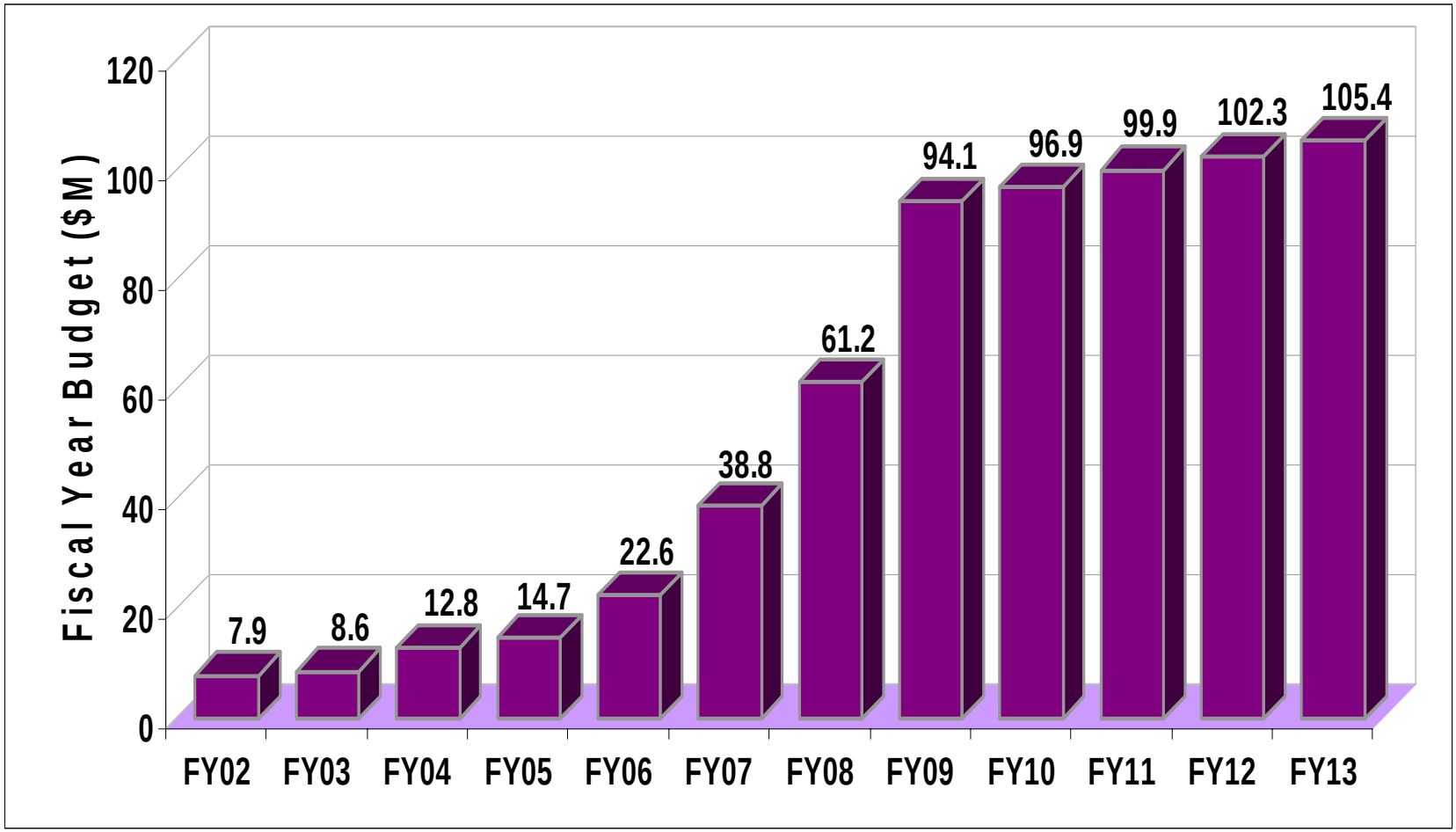
- **Test & Evaluation / Science & Technology (T&E/S&T) Program started in FY 2002**
  - **Joint DDR&E / DOT&E initiative**
- **Mission**
  - **Investigate and develop new technologies required to test and evaluate our transforming military capabilities**
    - **Include any system that makes our warfighters more survivable and effective in combat**
    - **Mature test technologies from TRL 3 to 6**
- **Goal**
  - **Transition emerging technologies into test capabilities in time to verify warfighting performance**

**Shaping Technology into Tomorrow's T&E Capabilities**

# T&E/S&T Program Office

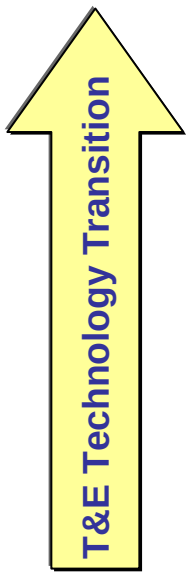
- **What We Do?**
  - Fund Test & Evaluation related R&D projects
  - Foster technology transition to MRTFB and other DoD T&E field activities
- **How We Do It?**
  - Issue annual Broad Agency Announcement (BAA)
  - Tri-Service working groups draft BAAs and participate in proposal evaluation
  - Award T&E R&D projects at TRL 3, 4 or 5 and mature to TRL 6
  - Executing Agents (EA) manage test technology Focus Areas
- **Who Do We Fund?**
  - Academia
  - Industry
  - Government laboratories
  - Teams of academia / industry / government labs

# T&E/S&T Program Annual Budget



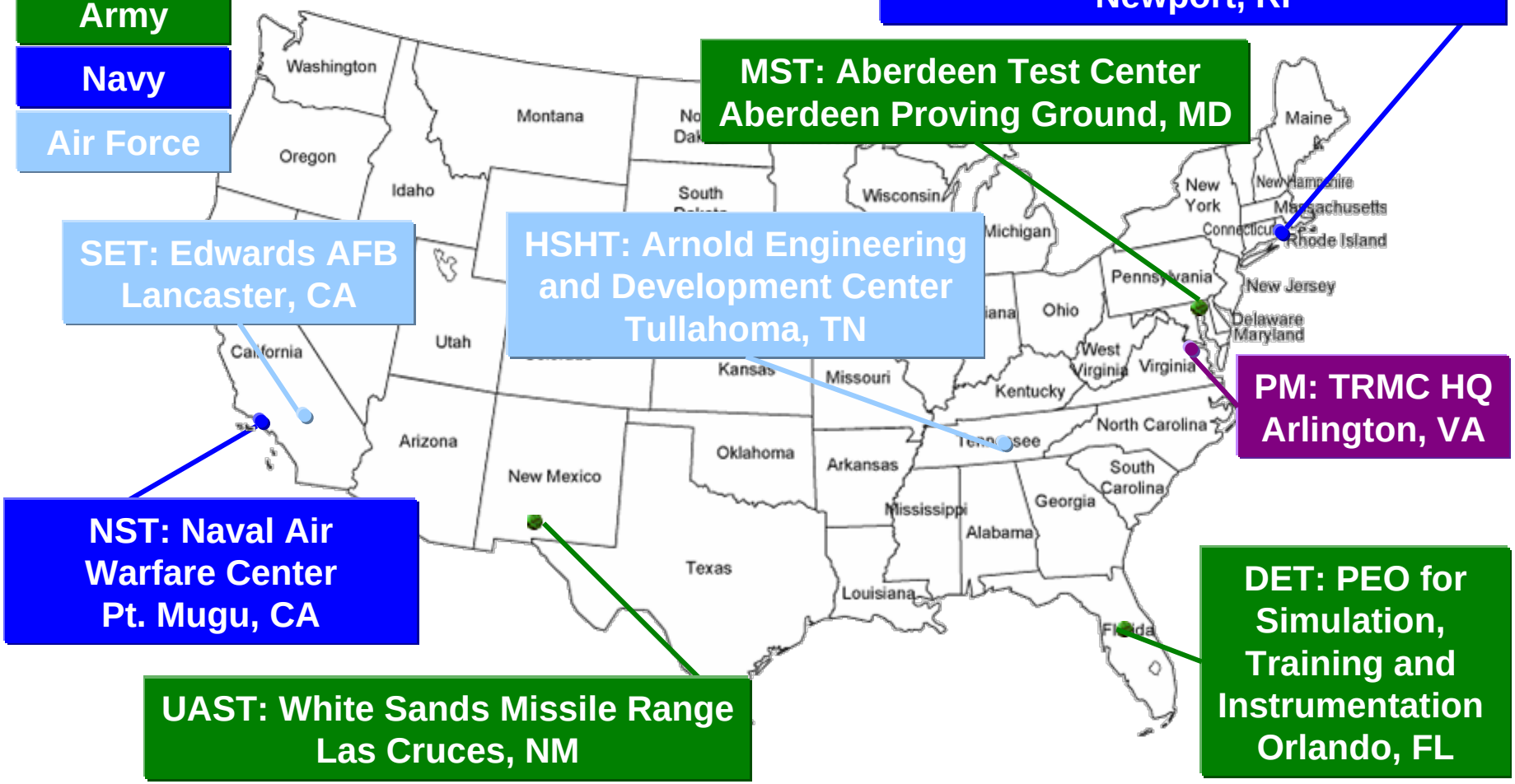
# Technology Readiness Level

| | |
|---|---|
| TRL 9 | Actual system 'flight proven' through successful mission operations |
| TRL 8 | Actual system completed and 'flight qualified' through test and demonstration |
| TRL 7 | System prototype demonstration in an operational environment |
| TRL 6 | System/subsystem model or prototype demonstration in a relevant environment |
| TRL 5 | Component and/or breadboard validation in relevant environment |
| TRL 4 | Component and/or breadboard validation in laboratory environment |
| TRL 3 | Analytical and experimental critical function and/or characteristic proof of concept |
| TRL 2 | Technology concept and/or application formulated |
| TRL 1 | Basic principles observed and reported |



# T&E/S&T Program Management

TRMC HQ
Army
Navy
Air Force




**Central Oversight – Distributed Execution**

# FY09 T&E/S&T Focus Areas

- **Directed Energy Test (DET) –** On-board and off-board technologies to assess performance of high energy laser and high power microwave weapon systems

- **High Speed/Hypersonic Test (HST) –** Technologies to provide high fidelity environments, M&S and instrumentation for ground and flight tests of air breathing hypersonic vehicle propulsion systems

- **Multi-Spectral Test (MST) –** Technologies to enable real-time, realistic T&E of multi-spectral and hyperspectral seekers and sensors through scene prediction, simulation and measurement

- **Non-Intrusive Instrumentation (NII) –** Technologies for non-intrusive sensors, power sources, time & positioning system, and data acquisition to provide continuous, non-obtrusive T&E

# FY09 T&E/S&T Focus Areas
(continue)

- **Netcentric Systems Test (NST) –** Technologies to measure and assess the performance of the physical, information domains of the Joint, integrated netcentric architectures

- **Spectrum Efficient Technology (SET) –** Technologies to enable more efficient use of legacy telemetry bands and expand into non-traditional areas of the RF spectrum and the optical spectrum

- **Unmanned Autonomous Systems Test (UAST) –** Technologies for T&E of unmanned systems ranging from full tele-operation to totally autonomous, learning performance

**Approximate 115 active projects**

# T&E/S&T Program
## Project Selection Process

**Drivers**

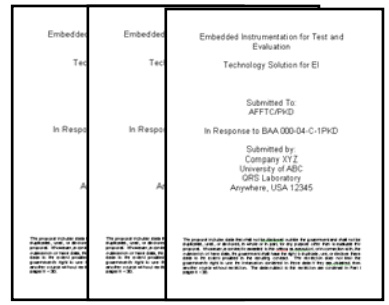
**Solicitations are issued through http://www.fedbizopps.gov**

**Tri-Service Focus Area Working Group**

- Executing Agent
- T&E Community Reps
- S&T Community Reps
- Subject Matter Experts

**Needs/Requirements**

**Roadmaps and Solicitations**



**Proposals**

**Source Selection Evaluation Team**

- Working Group
- Subject Matter Expert
- Contracting Reps

Recommendations

**Executing Agent**

Final Selections

**Program Manager**

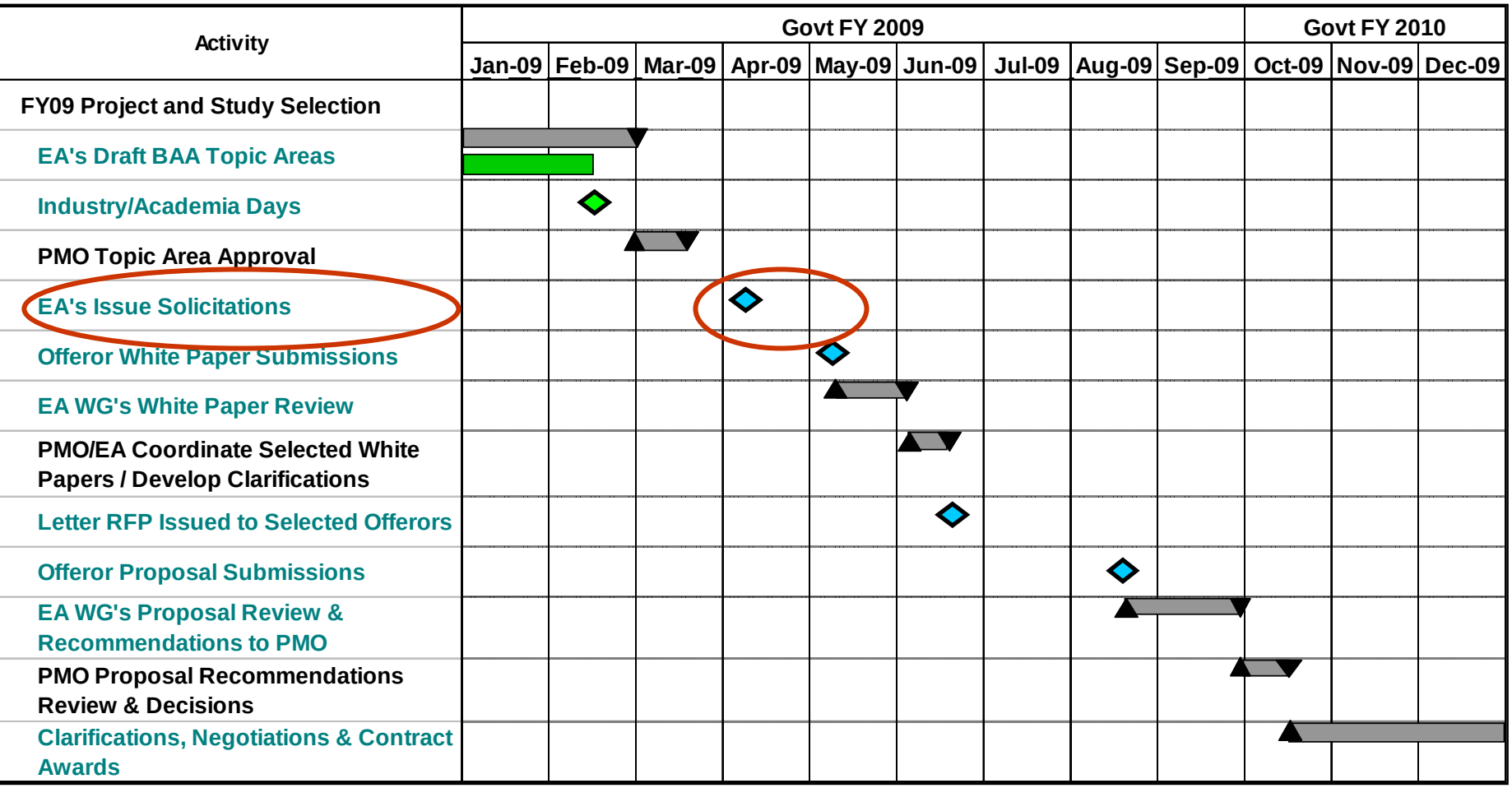
**Funding Decision**

Focus Area Execution

# Working Group Participants

| | | |
|---|---|---|
| Army | AMRDEC | IEW |
| | AMSAA | NVESD |
| | ARL | OTC |
| | ATC | PEO STRI |
| | ATEC | RDEC |
| | ATTC | RTTC |
| | HELSTF | TRADOC |
| Navy | NAVAIR | NAWC |
| | NAVSEA | NUWC |
| | NRL | SPAWAR |
| Air Force | AEDC | AFRL |
| | AFEWES | AFWDC |
| | AFFTC | 46th TW |
| | AFOTEC | 452nd FLTS |
| DoD | DDR&E | IO Range |
| | DISA / JITC | JCS |
| | DOT&E | JFCOM |

# BAA Schedule




BAA – Broad Agency Announcement
EA – Executing Agent
WG – Working Group
PMO – Program Management Office
RFP – Request for Proposal
FY – Fiscal Year

# FY10 BAA Release Schedule

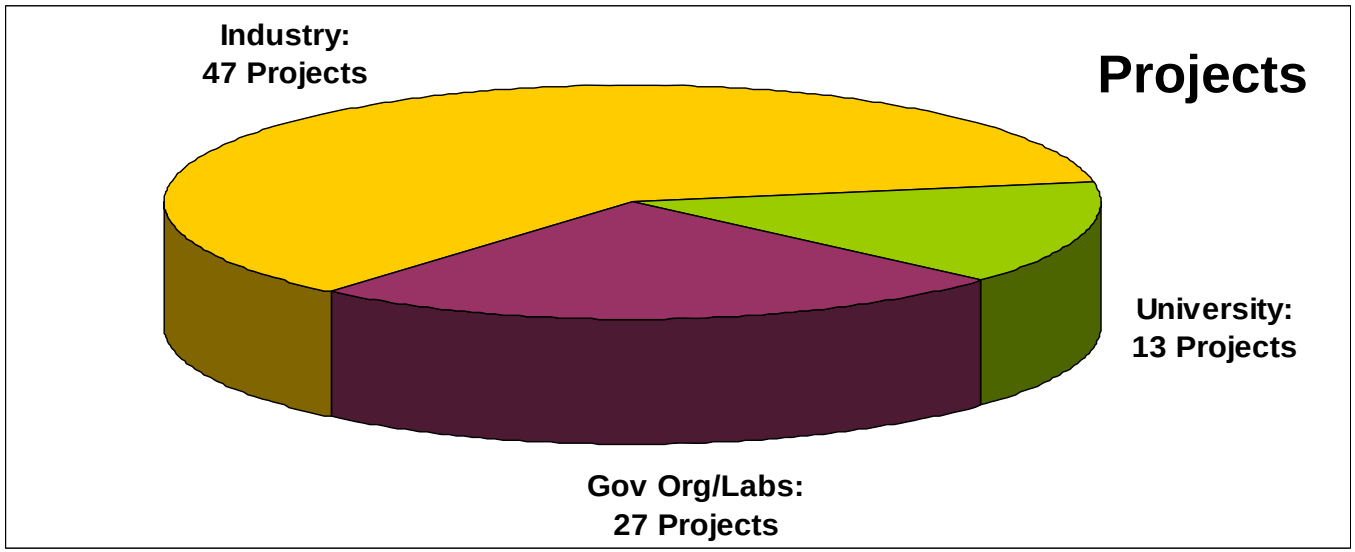
| | BAA Release | Whitepaper Due | "Invited" Proposal Due |
|---|---|---|---|
| Directed Energy Test | 3/25/09 | 5/1/09 | 7/29/09 |
| High Speed / Hypersonic Test | 4/15/09 | 6/2/09 | 8/25/09 |
| Multi – Spectrum Test | 4/2/09 | 5/1/09 | 8/4/09 |
| Non-Intrusive Instrumentation | By 4/30/09 | TBD | TBD |
| Netcentric System Test | 4/15/09 | 6/2/09 | 8/25/09 |
| Spectrum Efficient Technology | By 4/30/09 | TBD | TBD |
| Unmanned & Autonomous System Test | By 4/30/09 | TBD | TBD |

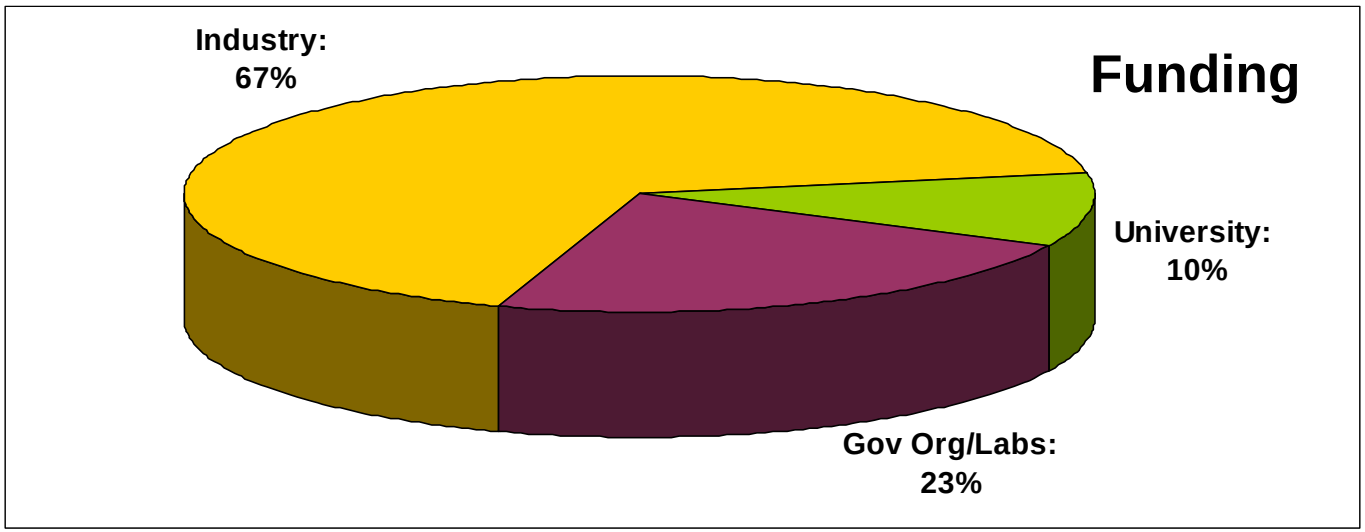
# FY10 BAA Announcements

http://www.fedbizopps.gov/ ➔ Search for “TRMC”

| | TRMC FY10 BAA RFP # |
|---|---|
| Directed Energy Test | W900KK-08-R-0012 |
| High Speed / Hypersonic Test | W900KK-08-R-0017 |
| Multi – Spectrum Test | W91ZLK-08-T-0211 |
| Non-Intrusive Instrumentation | W900KK-09-R-0037 |
| Netcentric System Test | W900KK-08-R-0018 |
| Spectrum Efficient Technology | W900KK-08-R-0019 |
| Unmanned & Autonomous System Test | W900KK-09-R-0038 |

# FY 2009 T&E/S&T Distribution




**Note**:
Numbers apply only to FY 2009 funding profile

# The Proposal — Key Criteria

- Meets a T&E Need
- Requires S&T work
- High Payoff
- Broad application (more than one DoD test activity)
- High potential for transition to development of a test capability

# Technology Development Needs

- **Fill gaps in existing T&E capabilities**
  - Implement new technology to existing systems
  - Satisfy immediate needs before new T&E capability become available
  - Meet urgent needs
- **Field components of T&E capabilities**
  - Improve current capability
  - Accept benefit–risk trade off
- **Develop new and integrated T&E capability**
  - Build state-of-the-art new T&E infrastructure
  - implement systems based on the latest technologies
  - Satisfy long-term version while meeting short-term goals

**TRMC Vision**

**The Department of Defense T&E Ranges & Facilities will be fully capable of supporting the Department with Quality products and services in a responsive and affordable manner.**

# Key T&E/S&T Focus Area Technology Investments

- **Directed Energy Test**
  - Measure energy on target
  - Visualize and assess target destruction mechanisms
- **High Speed/Hypersonic Test**
  - Clean air propulsion
  - Variable Mach Number nozzle
- **Multi-Spectral Test**
  - High spatial/spectral fidelity, high temperature, wide dynamic range, polarized and high frame rate scenes
  - Emitters and projectors encompassing more than one spectral band (i.e., Near Infrared, Short-Wave Infrared, and Mid-Wave Infrared)
- **Non-Intrusive Instrumentation**
  - High accuracy, high dynamic and GPS-denied TSPI
  - Scalable, open, wireless, self-healing architectures and smart sensors that support various interfaces
- **Netcentric Systems Test**
  - Live, virtual and constructive NST test environment that emulates real-world networks
  - Evaluate interoperability, net-ready KPP, and Joint mission effectiveness
- **Spectrum Efficient Technology**
  - Transmitters: Linear and constant envelope power amplifiers
  - Receivers: Low-noise amplifiers
  - Antennas: Point source trackers, Multi-beam phased arrays, Diversity (spatial, polarization, frequency) combiners
- **Unmanned and Autonomous Systems Test**
  - Predict autonomous performance and behavior
  - Accurately collect and compare autonomous systems situational awareness and ground truth

# MST Dynamic Hyperspectral Thermal Signature Model (DHTSM)

**Successfully demonstrated:**

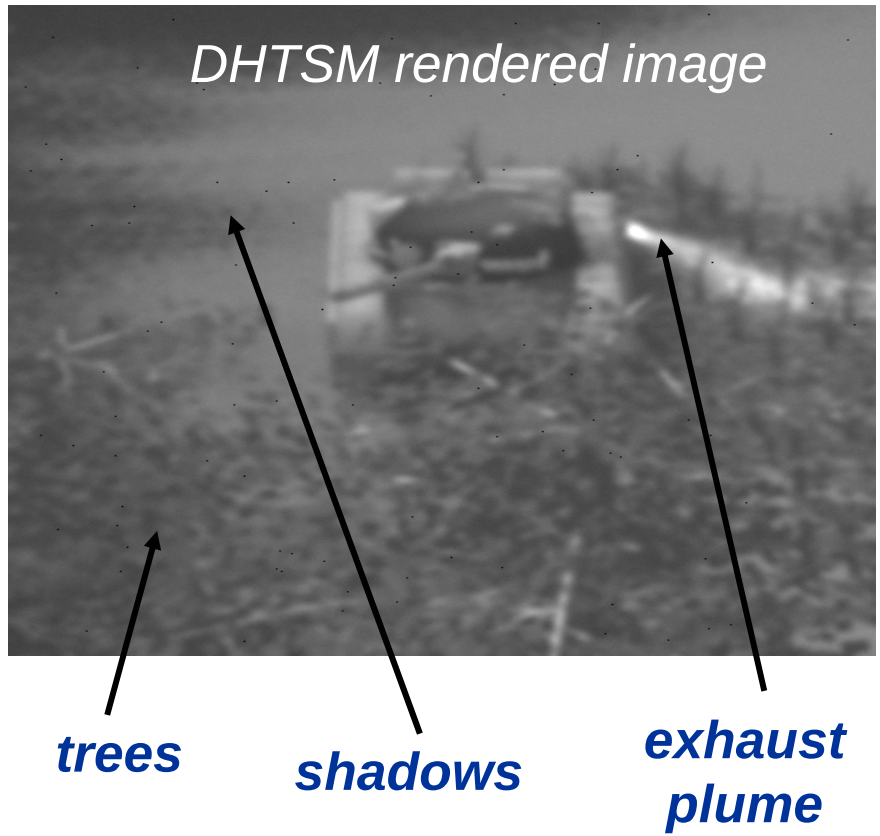
- **Large area (5 km x 5 km) long range infrared scenes**
- **High spatial and spectral fidelity; diurnal effects**
- **20-100 in-scene targets**

**Government owned source code; in use by**

- **Redstone Technical Test Center**
- **Army Aviation and Missile Research Development and Engineering Center**
- **Army and Air Force Research Labs**
- **National Ground Intelligence Center**
- **Natick Soldier Systems**
- **National Institute of Standards and Technology**
- **Night Vision and Electronic Sensors Directorate**

**Applications include missile testing, IR seeker dome design, camouflage evaluation, automatic target recognition, advanced hyperspectral sensor T&E**

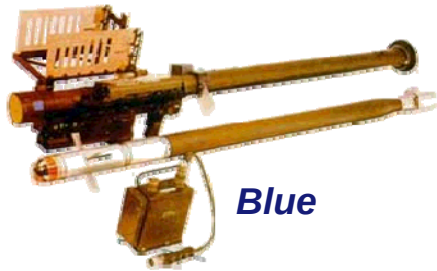
***Early Morning Summer Season***




***T62 Tank in a foliated environment***

# Infrared Countermeasures (IRCM) Drivers

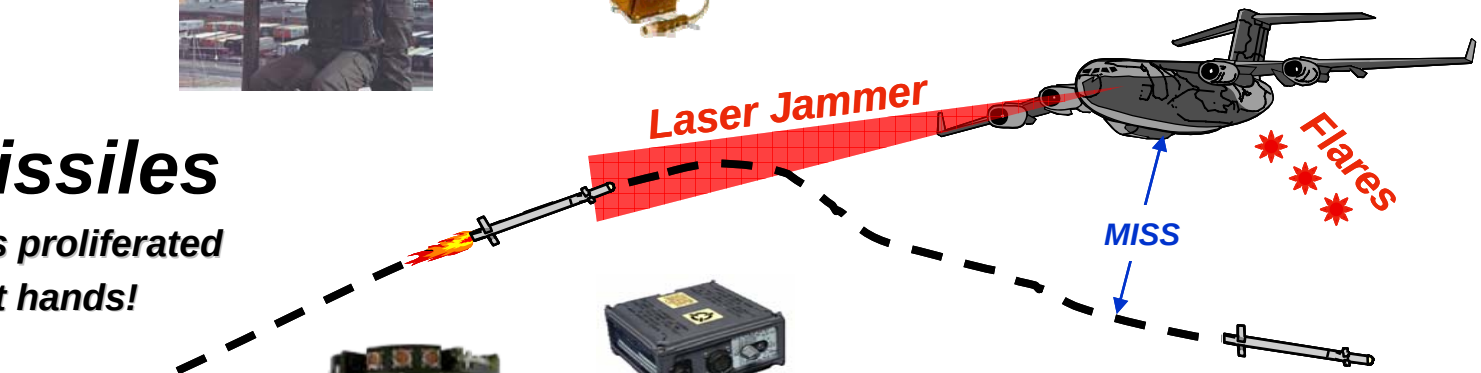






## Threat Missiles

- *Many thousands proliferated*
- *Many in terrorist hands!*

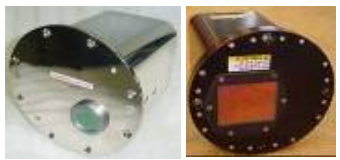



Laser Jamming

Flares

## IRCM Systems

UV Missile Warning



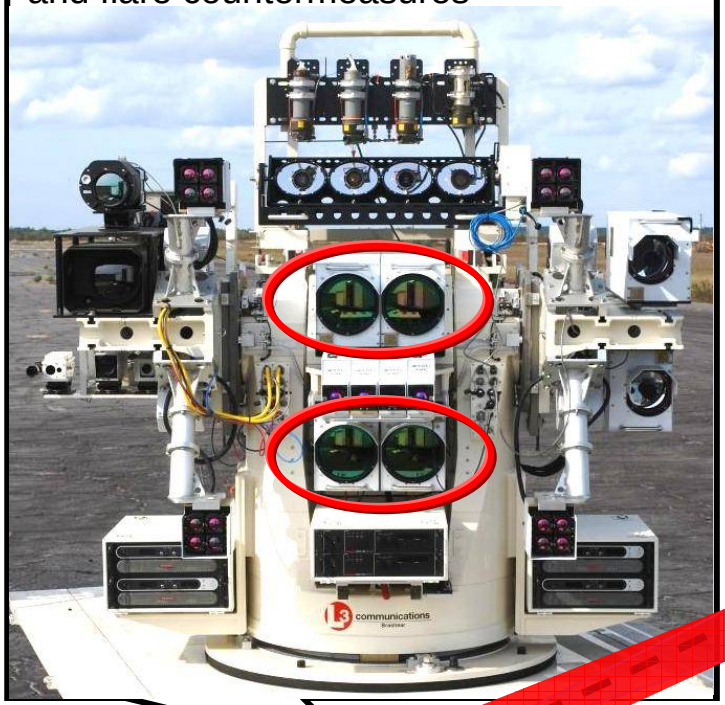
IR Missile Warning

**Advanced Development Systems**

- *Closed Loop Laser Jamming*
- *Visible Missile Warning*
- *Pro-Active (Jam Before Launch)*
- *Airport Protection*
- *HEL, HPM Countermeasures*

# Joint Mobile IRCM Test System (JMITS)

JMITS "paints" UV & IR signatures on IRCM systems and characterizes laser and flare countermeasures



*Both Units Delivered Directly to Test in Mar 08*

***Eglin AFB (DoN LAIRCM Testing on Navy CH-46)***

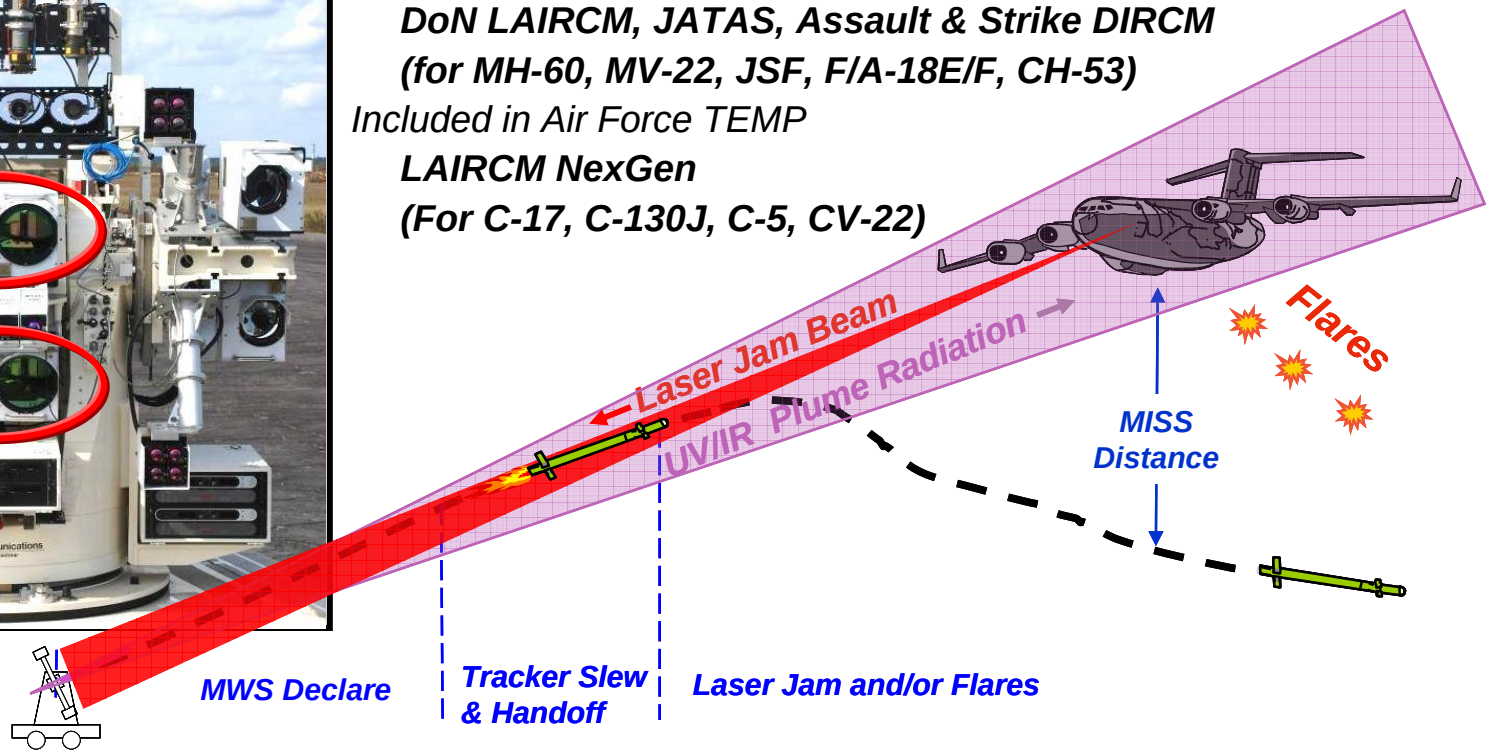
***China Lake (LAIRCM Testing on AFSOC CV-22)***

*Included in Navy TEMPS*

***DoN LAIRCM, JATAS, Assault & Strike DIRCM (for MH-60, MV-22, JSF, F/A-18E/F, CH-53)***

*Included in Air Force TEMP*

***LAIRCM NexGen (For C-17, C-130J, C-5, CV-22)***




**Required T&E/S&T Development for Higher Power Continuous Wave Infrared Sources**

- **To simulate long range shots within MANPAD operational envelopes**
- **To simulate longer range RF SAMs during multi-spectral testing (RF & IR)**
- **Two Colors (IR-Red & IR-Blue)**

# Summary

- Focus on technology transition to DoD's Major Range and Test Facility Base (MRTFB) and other T&E applications
- Develop and mature technology from TRL 3, 4 and 5 to TRL 6
- T&E Technology Development Partners
  - Industry
  - Academia
  - Government labs / ranges

# Questions?

## Contact Information:

**Mr. Gerry Christeson**

**Defense Test Resource Management Center**
**T&E / S&T Program**

**Gerald.Christeson@osd.mil**

# Back Up

# Directed Energy Test

## T&E Gaps

- Ability to visualize laser energy on a target to determine beam location, beam pointing, and tracking stability
- Ability to visualize target destruction mechanisms resulting from laser heating
- Ability to model reflectance from a target to assess target destruction mechanisms
- Ability to non-intrusively measure high-power microwave (HPM) fields to assess quality
- Ability to assess HPM target destruction mechanisms or field uniformity for active denial systems

## S&T Challenges

- Develop passive adaptive optics to map laser spot on target (High Energy Laser [HEL])
- Develop high frame rate multi-band infrared cameras (HEL)
- Develop co-located irradiance and temperature sensors on conformal target boards (HEL)
- Develop algorithms to quantify dynamic target surface temperature (HEL)
- Develop non-intrusive, compact, HPM electro-optical and magneto-optical sensors (HPM)
- Develop advanced HPM target board (HPM)

## Major Developments

- HEL temperature and irradiance target panel
- Stand-off sensing of HEL target illumination
- On-board sensing of HEL target illumination
- Electric and magnetic field sensors for HPM effects testing using wide-band and narrow-band sources
- Target board for Active Denial System

## Budget ($M)

| FY08 | FY09 | FY10 | FY11 | FY12 | FY13 | FY14 | FY15 |
|---|---|---|---|---|---|---|---|
| 15.0 | 18.7 | 21.7 | 21.2 | 19.7 | 20.1 | 20.5 | 20.9 |

# High Speed/Hypersonic Test

## T&E Gaps

- Ability to test hypersonic propulsion systems in real air conditions in wind tunnels
- Ability to simulate flight vehicle speed changes in ground test for propulsion testing
- Ability to model ground test facilities to predict test results, optimize testing for limited test time, and reduce flight test risk
- Limited ability to non-intrusively measure temperature, pressure, heat flux, or chemistry
- Limited ability to efficiently gather vehicle performance data during flight test

## S&T Challenges

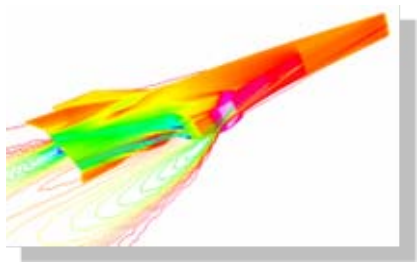
- Research and develop high temperature and high pressure heaters for clean air impulse and continuous flow ground test facilities
- Develop flow control to provide variable Mach
- Research and develop arc heater simulation and control mechanisms for ground test
- Research and develop temperature, pressure, heat flux, and chemistry sensors for hypersonic ground and flight test
- Develop optimized test techniques to obtain flight characteristics in an efficient manner

## Major Developments

- Conducting parallel research efforts to obtain clean air and variable Mach in ground test facilities
- Evaluating the effects of combustion products from fuel used to heat air in hypersonic flow for propulsion testing
- Systematically comparing test results between different ground test facilities to better predict and assess data collected in all facilities

## Budget ($M)

| FY08 | FY09 | FY10 | FY11 | FY12 | FY13 | FY14 | FY15 |
|---|---|---|---|---|---|---|---|
| 16.0 | 17.8 | 19.0 | 19.1 | 19.2 | 19.5 | 19.9 | 20.3 |



# Multi-Spectral Test

## T&E Gaps

- Ability to present accurate, high resolution battle scenes for sensor testing (e.g. missile warning system)
- Ability to present temperature ranges for missile plumes and afterburners for sensor stimulation
- Ability to stimulate sensors by projecting simulated scenes in real-time (trick sensor into responding to simulated data)
- Ability to project and inject spatially and temporally correlated high frame rate scenes for hyperspectral and multi-spectral seeker testing

## S&T Challenges

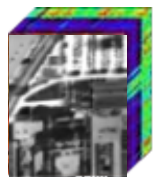
- Develop large-scale hyperspectral signatures and scenes
- Develop real-time, high frame rate battlespace representations with high spectral and spatial resolution
- Develop spatially and temporally correlated dynamic infrared and radio frequency scenes and targets
- Develop realistic spectral radiance and high dynamic range across environmental conditions
- Develop technologies to present high temperature (≥3,000°C) emitters

## Major Developments

- Emitters and projectors encompassing more than one spectral band (*i.e.*, Near Infrared, Short-Wave Infrared, and Mid-Wave Infrared)
- High temperature, real-time scene generation using 3-D atmospheric models (more accurate than any existing model)
- High power carrying optical fibers for infrared countermeasure testing

## Budget ($M)

| FY08 | FY09 | FY10 | FY11 | FY12 | FY13 | FY14 | FY15 |
|---|---|---|---|---|---|---|---|
| 9.5 | 12.7 | 12.7 | 12.7 | 13.1 | 13.2 | 13.5 | 13.7 |



# Non-Intrusive Instrumentation

## T&E Gaps

- Non-intrusive, miniaturized sensors and data storage technologies, and supporting architectures
- Miniaturized, long operational life, and efficient power and energy management in a chip
- Data collection for reporting human operator time-space-position information (TSPI) in GPS-denied environments
- High accuracy TSPI for highly dynamic platforms

## S&T Challenges

- Develop next generation MEMS, fiber optic sensors, and holographic memory devices
- Develop scalable, open, wireless, self-healing architectures and smart sensors that support various interfaces
- Develop power sources and power mixer-charger-supply electronics embedded within a chip (e.g., lithium-ion strip battery and methanol fuel cell)
- Develop high-resolution location information systems using wide-band, anti-jam technology

## Major Developments

- On-board wireless data communication
- Non-perturbing pressure, temperature, chemical species probes (*e.g.*, MEMS and optical)
- TSPI in GPS-denied environments using wideband radio frequency
- Ultra-high dynamic GPS
- Advanced in-situ power sources to support long-term measurements

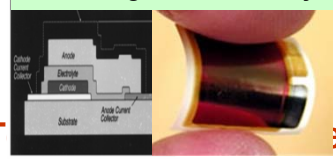
**15 active projects**

## Budget ($M)

| FY08 | FY09 | FY10 | FY11 | FY12 | FY13 | FY14 | FY15 |
|---|---|---|---|---|---|---|---|
| 7.5 | 4.8 | 4.9 | 6.6 | 8.6 | 9.9 | 10.0 | 10.2 |

Holographic Memory Cube

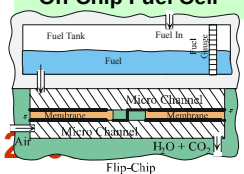
In-Package Li-Ion Battery



Self-Powered Chip

1 cm x 1 cm

On-Chip Fuel Cell



# Netcentric Systems Test

## T&E Gaps

- Higher fidelity M&S of netcentric battlespace components, and high fidelity network emulation
- Accurately represent effects of the command and control (C2) structure and decision processes
- Representation of Joint mission threads of kinetic and non-kinetic warfighter capabilities
- Ability to evaluate interoperability, net-ready KPP, and Joint mission effectiveness
- Automated intelligent capability to plan, execute, construct, and visualize a netcentric test environment

## S&T Challenges

- Develop algorithms to integrate and validate complex simulations in netcentric environments
- Develop algorithms to dynamically manage the test network and conduct compliance testing
- Automate test planning; scenario development; test environment construction; and data capture, analysis, and visualization of netcentric measures
- Represent multiple layers of the C2 structure and simulate the decision processes output

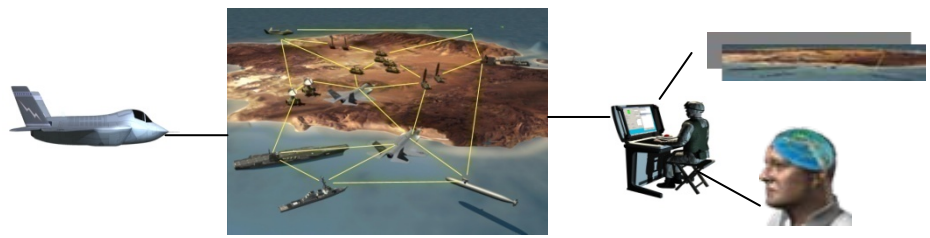
## Major Developments

- High fidelity representation and visualization of current and emerging networks
- Live-Virtual-Constructive (LVC) testing to characterize network effects
- Dynamically configure distributed LVC networks with improved efficiency and performance
- Simulate and analyze effects of traditional and non-kinetic actions within Joint mission context
- Manage and analyze the Joint netcentric test environment in real-time or near real-time

**18 active projects**

## Budget ($M)

| FY08 | FY09 | FY10 | FY11 | FY12 | FY13 | FY14 | FY15 |
|---|---|---|---|---|---|---|---|
| 9.0 | 13.2 | 16.1 | 18.0 | 18.5 | 18.8 | 19.2 | 19.5 |



# Spectrum Efficient Technology

## T&E Gaps

- Ability to transmit higher data rates in reduced bandwidth environments
- Ability to dynamically allocate frequency bands
  - Ability to detect and use available portions of the spectrum
- Ability to operate in super-high frequency
- Ability to use newly acquired spectrum
- Need Quality of Service (QoS) management software

## S&T Challenges

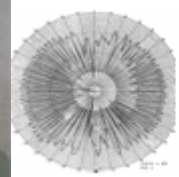
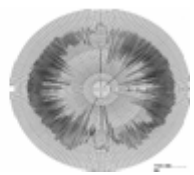
- Develop more efficient modulation and signal coding techniques for greater efficiency (higher data rates in the same bandwidths)
- Develop software for the iNET radio frequency (RF) management telemetry application
- Develop multi-band transmitters and broadband antennas
- Develop QoS management software and simulation tools

## Major Developments

- Mitigation of interference between two transmitter antennas
- Simulations to address iNET networking requirements
- RF channel model development to perform ground station system design
- Increased efficiency of linear RF power amplifiers (improved efficiency from 20% to 30%)

## Budget ($M)

| FY08 | FY09 | FY10 | FY11 | FY12 | FY13 | FY14 | FY15 |
|---|---|---|---|---|---|---|---|
| 1.2 | 6.2 | 6.2 | 11.1 | 11.3 | 11.5 | 11.7 | 11.9 |


# Unmanned & Autonomous System Test

## T&E Gaps

- Ability to safely test lethal, intelligent, tele-operated, or autonomous platforms
- Ability to predict autonomous performance and behavior
- Ability to instrument small unmanned and autonomous systems (UAS) without affecting design or performance
- Ability to accurately collect and compare autonomous systems situational awareness and ground truth

## S&T Challenges

- Develop “fail-safe” methods to control and disarm weaponized UAS safely, even under operational control systems failure
- Develop predictive behavior models by integrating genetic algorithms and probability theory
- Develop models capable of applying realistic stimuli to systems under test
- Develop on- and off-board instrumentation and test communications networks that do not impact UAS performance

## Major Developments

- Multi-data collection sensor system for on-board data capture and real-time measurement at system and sub-system levels for “fail-safe” management and performance assessment
- Modular, self-powered system (<10g) that provides continuous tracking, position, and orientation data
- Situational awareness technologies to perform safe and detailed tests of multiple platforms in diverse environments

**13 active projects**

## Budget ($M)

| FY08 | FY09 | FY10 | FY11 | FY12 | FY13 | FY14 | FY15 |
|---|---|---|---|---|---|---|---|
| 4.1 | 6.3 | 6.4 | 6.3 | 6.5 | 6.5 | 6.6 | 6.8 |

# T&E Needs

**The R&D project:**

- **Addresses the T&E requirements**
- **Fills known T&E gaps**
- **Articulates how the above are to be achieved**

**Example: T&E Need**

**Ground test facilities generally use combustion processes to create representative flight conditions for hypersonic engine testing. The effects of vitiates on the engine performance is not well known. Ground test facilities need a clean air test capability to more realistically simulate actual flight conditions to accurately predict engine performance in flight.**

# S&T Challenges

**The R&D project:**

- **Develops new test & evaluation capabilities that do not currently exist**
- **Utilizes /develops beyond state-of-the-art technologies that can be high-risk**
- **Pushes technology to new limits**

**Example: S&T Challenges**

- Develop resistively heated elements to routinely operate between 2200 to 2400 Kelvin (4535 to 4927 deg F)
- Develop electrical interface materials that can maintain high current (60 Amp or greater) electrical and mechanical connection at extreme temperatures
- Develop element materials and shapes that can withstand temporal temperature cooling gradients of at least a thousand degrees a minute and maintain air seal to prevent internal cooling air from leaking into external airflow and cooling it

# Partnerships

- **Partnerships between universities, industry & DoD laboratories**
  - **Form the best research teams possible**
- **Collaborate to pursue bigger opportunities**
  - **Leverage each others' core competencies**
  - **Share resources**
- **Increase transition opportunities through increased involvement in the T&E/S&T Program**