



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

**Tom Macdonald
Advanced Instrumentation Systems Technology (AIST)
Consultant**

**Precision Indoor Personnel Location and
Tracking for Emergency Responders Workshop
2 August 2010**



Outline

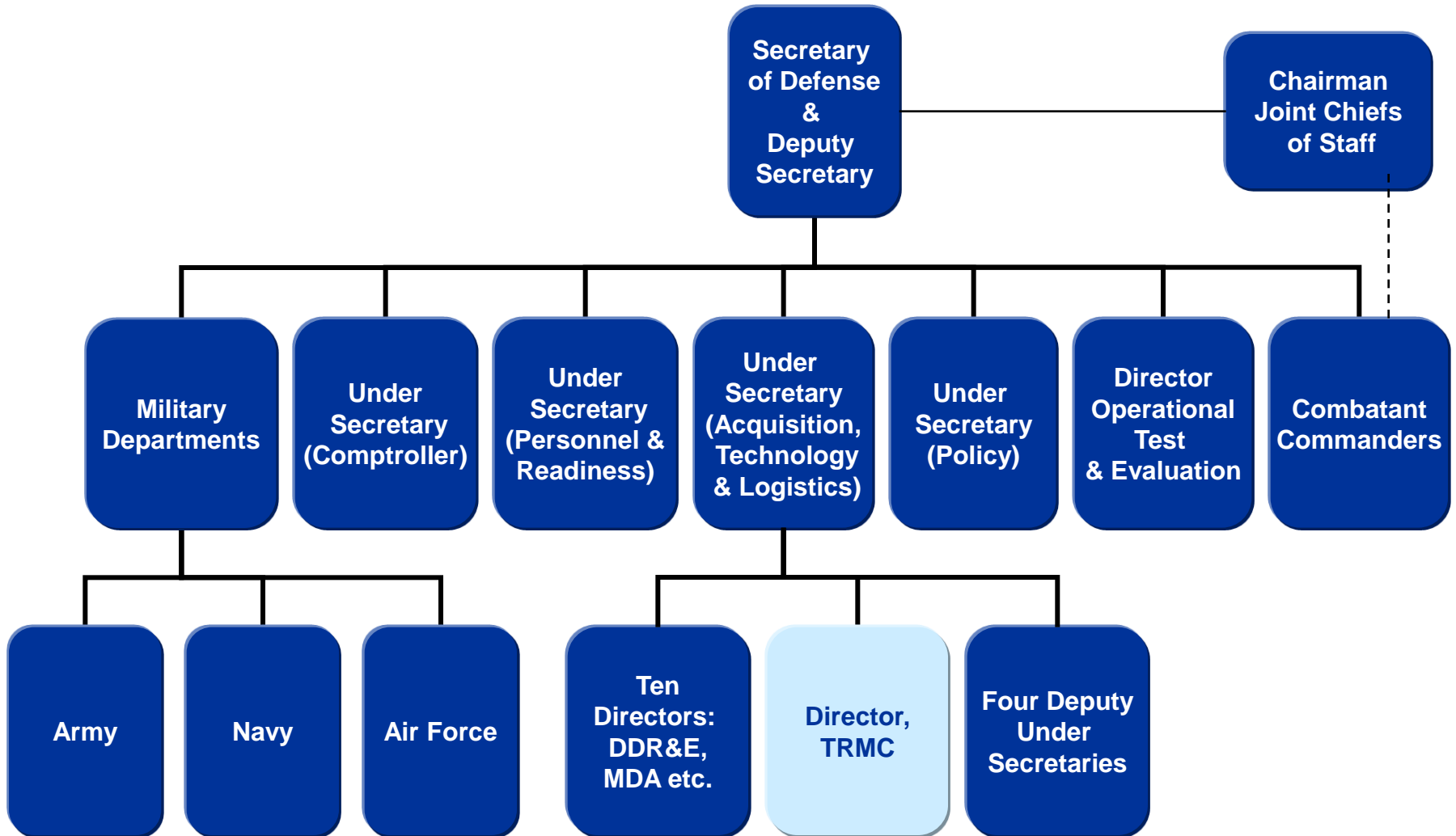


- **Test Resource Management Center (TRMC)**
- **T&E/S&T Program**
 - **Advanced Instrumentation Systems Technology Area**



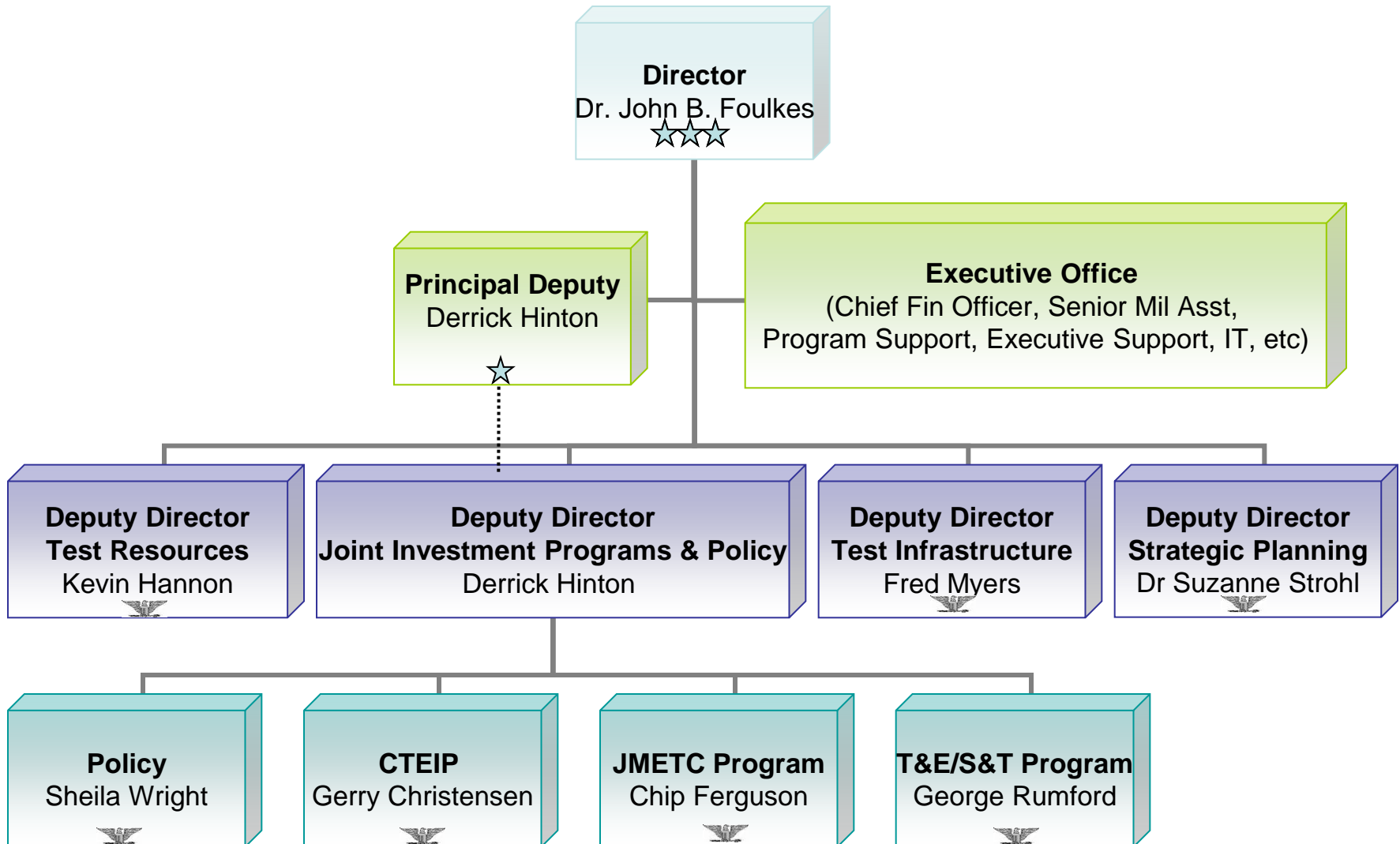
TRMC T&E/S&T

Direct Report to USD(AT&L)





TRMC Organization





T&E/S&T Program Office
 G. Rumford, Program Manager
 R. Heilman, Deputy Program Manager

Support Staff

Advanced Instrumentation Systems Technology
 G. Shoemaker, EA
 J. Hooper, Deputy EA

Advanced Propulsion Test Technology
 T. Fetterhoff, EA
 S. Bancroft, Deputy EA

Directed Energy Test
 M. Vuong, EA
 S. Morton, Deputy EA

Multi-Spectral Test
 F. Carlen, EA
 L. Huynh, Deputy EA

Subject Matter Experts

Tri-Service Working Group

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Tri-Service Working Group

NetCentric Systems Test
 G. Torres, EA
 [Vacant], Deputy EA

Spectrum Efficient Technology
 T. Young, EA
 [Vacant], Deputy EA

Unmanned and Autonomous Systems Test
 F. Macias, EA
 M. Rivas, Deputy EA

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Legend

Green – Army Lead

Purple – Joint/Multi-Service

Blue – Navy Lead

Gray – Not Service-Specific

Light Blue – Air Force Lead



T&E/S&T Program Office



- **What We Do?**

- Fund high risk / high pay-off T&E 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 starting at TRL3 and mature to TRL6
- Executing Agents (EA) manage Test Technology Areas

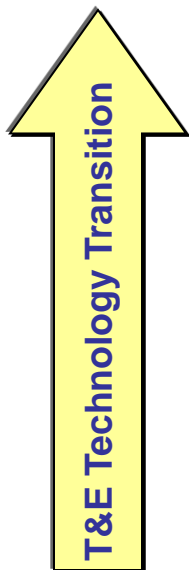
- **Who Do We Fund?**

- Academia
- Industry
- Government laboratories
- Teams of academia / industry / government labs



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





Needs and Challenges

T&E Needs

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

S&T Challenges

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



Advanced Instrumentation Systems Technology (AIST) Test Technology Area



AIST Overview

AIST will advance the field of device physics by investigating innovative materials, MEMS sensors, data transformation and novel packaging technologies to support T&E of warfighting systems

Advanced Sensors

Non-intrusive, miniature and hardened for harsh environments

TSPI

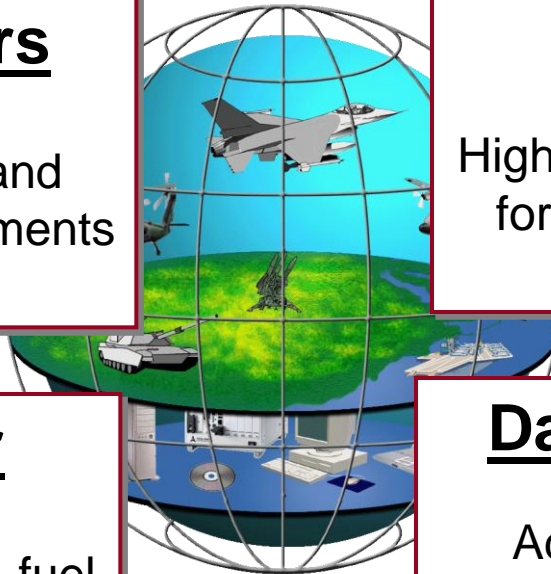
High accuracy & continuous TSPI for high speed/high-G & GPS-denied environments

Advanced Power

Next generation hybrid ionic, fuel cell based & harvesting techniques

Data Transformation

Advanced data acquisition, processing, mining, & storage. Digital & synthetic instrumentation.



Vision

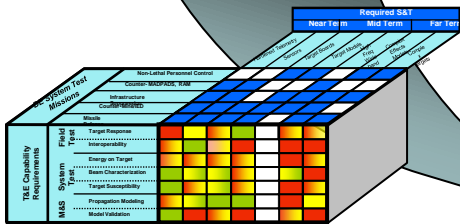
Advanced Technology Demonstration Programs



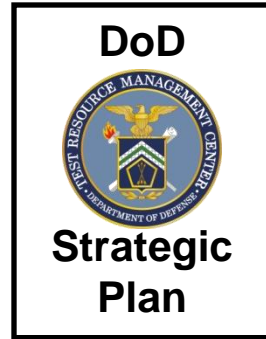
AFRL **ARL**

DoD Agencies **ONR** **NRL**

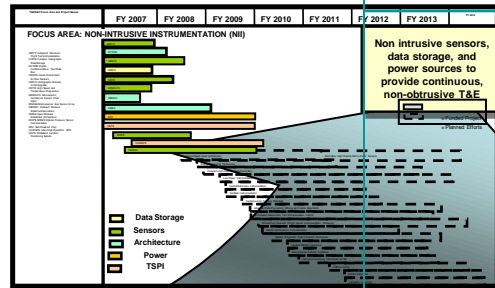
T&E Gaps



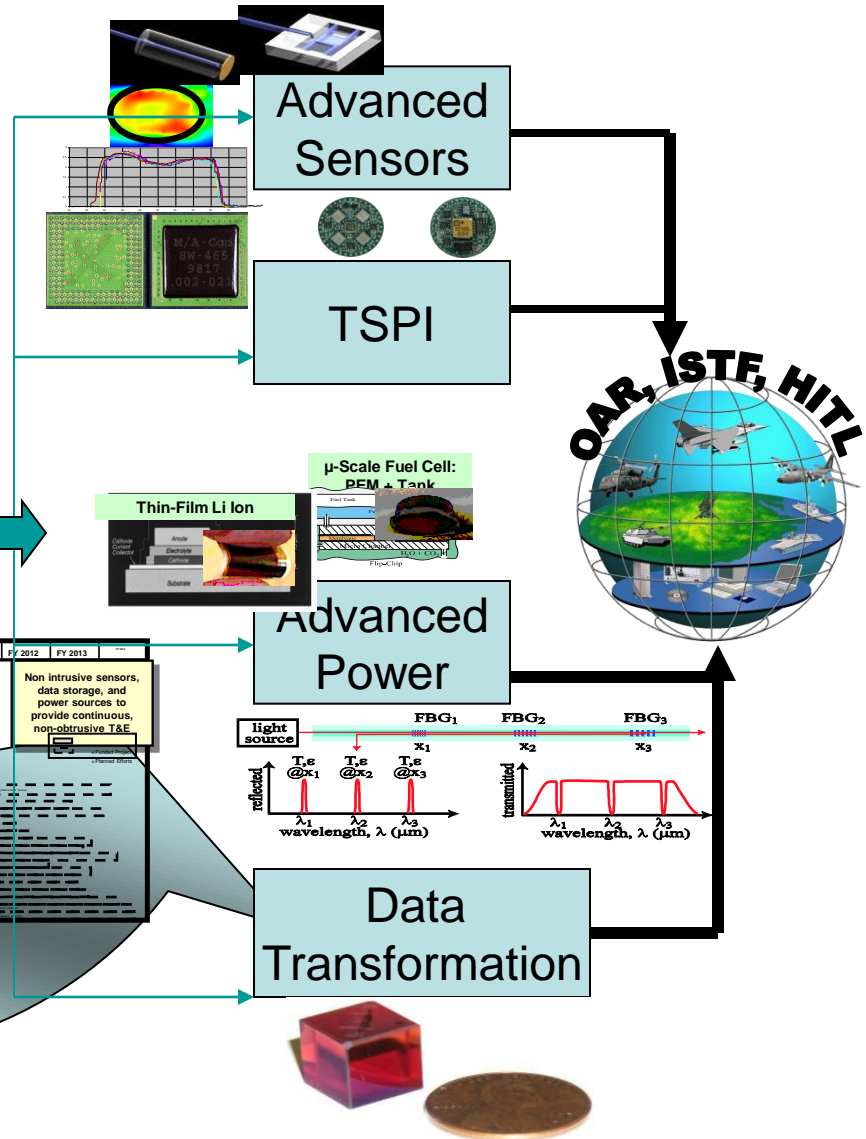
Next Gen TSPI Study



AIST Roadmap



AIST WG





AIST in Support of TSPI in GPS-Denied Environments



- **Implement aspects of the Next-Gen TSPI Roadmap**
- **Currently have three time-space-position information (TSPI) projects in AIST portfolio**
 - **Triply Redundant Navigation and Asset Visibility (TRINAV)**
 - **Wideband Local Positioning System (WLPS)**
 - **Ultra-High Dynamics GPS Receiver (UHDGPS)**
- **Two new projects will start up this year**
- **Expect TSPI as a major thrust of the AIST BAA for several years**
- **These efforts will support the under-development Joint Urban Test Center (JUTC)**



TSPI Solution is a Multi-Sensor Problem

- **Tracking Dismounted Warfighters**
- **Intelligent Fusion Algorithms**
 - Enhanced inertial measurement units (IMUs)
 - RF and other Ranging technologies
 - Enhanced GPS
 - Visual Reference systems
- **Body Orientation**
 - IMUs
 - Bend and Force Sensors
 - Optical Fiber methods
- **Personal Weapon/Sensor Pivot Point and Orientation**
 - Magnetic Compass & Algorithms
 - Attitude capable GPS
 - IMUs



Ultra High Dynamics GPS Receiver (UHDGPS)



T&E Gap

- There is need for a multi frequency capable GPS receiver using new GPS signals and techniques to provide ultra high dynamics performance with operation up to 5 km/s and GPS tracking up to 1,000g.

S&T Challenges

- Develop method to acquire & track new GPS signals using a hybrid receiver approach at very high speeds
- Anti-jam capability
- Multi frequency operation
- Exceeds current state of the art dynamics by 20x

TRL START/FINISH 3/5

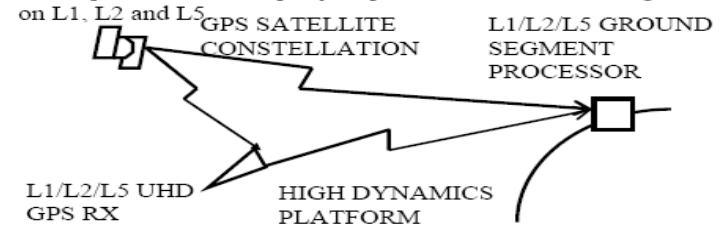
Description

- Phase 1: FPGA Platform Design & Development. Simulation and Architecture design
- Phase 2: Design, develop, code and demonstrate L2C acquisition and track.
- Phase 3: Design, develop, code and demonstrate L5 acquisition and track.
- Phase 4: Integrated Receiver Development and Test. Demonstrate/test using satellite simulators. Develop final report.

Deliverables

Ultra High Dynamics GPS Operating Principle

A high performance FPGA using advanced FFT hybrid receiver techniques in order to rapidly acquire and track the GPS signals on L1, L2 and L5



Integrated receiver design & testing
Results & brassboard hardware



Wideband Local Positioning System (WLPS)



T&E Gap

- Ability to locate soldiers and UGVs in GPS-denied/impaired areas such as inside buildings and complex structures

S&T Challenges

- Determine accurate position measurement (< 0.16 meter)
- UWB propagation delay and attenuation through varied materials
- Pseudorandom Noise (PRN) sequences and waveform
- Advanced Tracking algorithms

TRL START/FINISH 3/6

Description

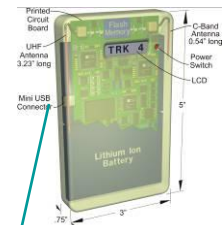
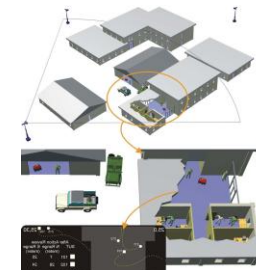
Phase 1: receiver & transmitter prototype, bench testing, & open air test.

Phase 2: receiver frequency reference design, tests, & open air demo at GTRI

Phase 3: power conservation prototype, miniature embedded receiver, miniature receiver tests, design & fab of 4 portable transmitters, open air tests.

Phase 4: demonstration testing at Aberdeen Test Center.

Deliverables



- Four transmitters
- Receivers
- Test Results
- Final Report





Triply-Redundant Integrated Navigation & Asset Visibility System (TRI-NAV)



T&E Gap

- Threshold location accuracy of ± 3 m, indoors or outdoors; the objective figure is ± 1 m.
- Precise time acquisition accuracy of < 100 μ s permits direct acquisition of P(Y) code GPS in a partial-jamming situation and is another general DoD TSPI requirement.

S&T Challenges

- Calibration and signal processing algorithms for quartz oscillators for use as an INS,
- Development of compact TPS antennae.
- Integration of GPS/TPS/INS technologies.

- TRL Start/Finish e.g. 3-6

Description

Year 1

- Task 1: R&D of TPS radiolocation receiver, new 3-axis antenna.
- Task 2: R&D of cubic, ovenized EQUATE lab prototype.
- Task 3: Optimize dual-mode oscillator, signal-processing electronics; evaluate potential ASIC circuit topologies.

Year 2

- Task 1: Evaluate EQUATE timekeeping & INS functions; begin ASIC design.
- Task 2: Complete R&D of low-power, dual-mode EQUATE unit.
- Task 3: Package 7-channel EQUATE unit into ~ 2 -cm cube.
- Task 4: Integrate TPS & EQUATE subsystems into TRI-NAV test unit.

Year 3

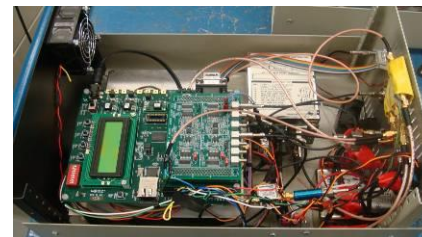
- Task 1: Refine electronics & ASICs for stability, low power; retest.
- Task 2: Lab-test prototype TRI-NAV vs. benchmarks; field test vs. GPS.
- Task 3: Field test & optimize prototype TRI-NAV T&E unit.

Year 4

- Task 1: Lab-test final TRI-NAV unit vs. benchmarks; field test vs. GPS.

Deliverables

- 4 Theater Positioning System (TPS) transmitters
- High Quality DGPS receiver
- MEMS Inertial Navigation System



TPS Transmitter



Receiver



Summary

- **TRMC is funding AIST GPS-denied technology development (focus of this brief)**
- **TRMC is also funding**
 - **GPS-denied study and technology roadmap development**
 - **JUTC development**
- **BAA is about to be released to further the development of promising GPS-denied technologies**