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

Approved for Public Release
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)
T&E/S&T Program Office
G. Rumford, Program Manager
R. Heilman, Deputy Program Manager

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

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

Subject Matter Experts
Tri-Service Working Group

Support Staff

Legend
Green – Army Lead
Blue – Navy Lead
Light Blue – Air Force Lead
Purple – Joint/Multi-Service
Gray – Not Service-Specific
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

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

**Cost to Achieve**

**T&E Technology Transition**
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

DoD Strategic Plan

AIST Roadmap

Advanced Sensors

TSPI

Advanced Power

Data Transformation

Non-Lethal Personnel Control Counter-MADPADS, RAM Infrastructure Suppression Counter-Mine/IED Missile Defense

T&E Capability Requirements M&S System Test Field Test Propagation Modeling Model Validation Beam Characterization Target Susceptibility Interoperability Energy on Target Target Response

Near Term Mid Term Far Term

Required S&T

Advanced Sensors

T&E/S&T Focus Area and Project Names

FOCUS AREA: NON-INTRUSIVE INSTRUMENTATION (NII)

Non intrusive sensors, data storage, and power sources to provide continuous, non-obtrusive T&E

AMFTI: Advanced Munitions Flight Test Instrumentation

CHDS: Compact Holographic Data Storage

DCTDB: Digital Communications Test Data Bus

HEDFS: Harsh Environment D-Fiber Sensors

HMCU: Holographic Memory Cube Upgrade

HSTD: High Speed and Temperature Diagnostics

MEMS FO: Microelectro-mechanical System Fiber Optic

MSGSA: Multi-species Gas Sensor Array

OBWDC: Onboard Wireless Data Communications

OMEA: Open Modular Embedded Architecture

MOPS: MEMS Optical Pressure Sensor Instrumentation

SPC: Self-Powered Chip

UHDGPS: Ultra High Dynamics GPS

WLPS: Wideband Location Positioning System

OMEA

DCTDB

HEDFS

MEMS FO

HMCU

Synthetic Instrumentation

Low Power Instrumentation

Distributed Autonomous Test Instrumentation Control

Miniaturized Reduced Weight Sensor Instrumentation Packaging

Advanced Data Processing, Mining and Fusion Algorithms

Human Performance instrumentation

Vehicle Power Lines as Data bus

Alternative High Density Micro-Power Sources

Non-intrusive Network Interfaces

Techniques for Applying Metadata

Compact High Capacity Data Recorders

Anti-jam Processing Techniques for NII

Tunable MEMS Transceiver TSPI on a Chip

Electro-Adhesives

System of Systems Data Collection Techniques

Inertial Reference Instrumentation

Energy Harvesting Techniques

Telemetry on a Chip

Next Gen TSPI Study

AIST WGs

AFRL

ARL

DoD

ONR

NRL

T&E Gaps

DoD Agencies

Advanced Technology Demonstration Programs

JSP

AIST Roadmap

Advanced Power

Data Transformation

Next Gen TSPI Study

AIST WGs
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.

---

**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**
## 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

## Description

**Phase I:** 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 μs permits direct acquisition of P(Y) code GPS in a partial-jamming situation and is another general DoD TSPI requirement.

**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.

**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

**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