Fuze Science and Technology Overview

2017

George Jolly
Ordnance Division
AFRL Munitions Directorate

Integrity | Service | Excellence

RW Intro Video

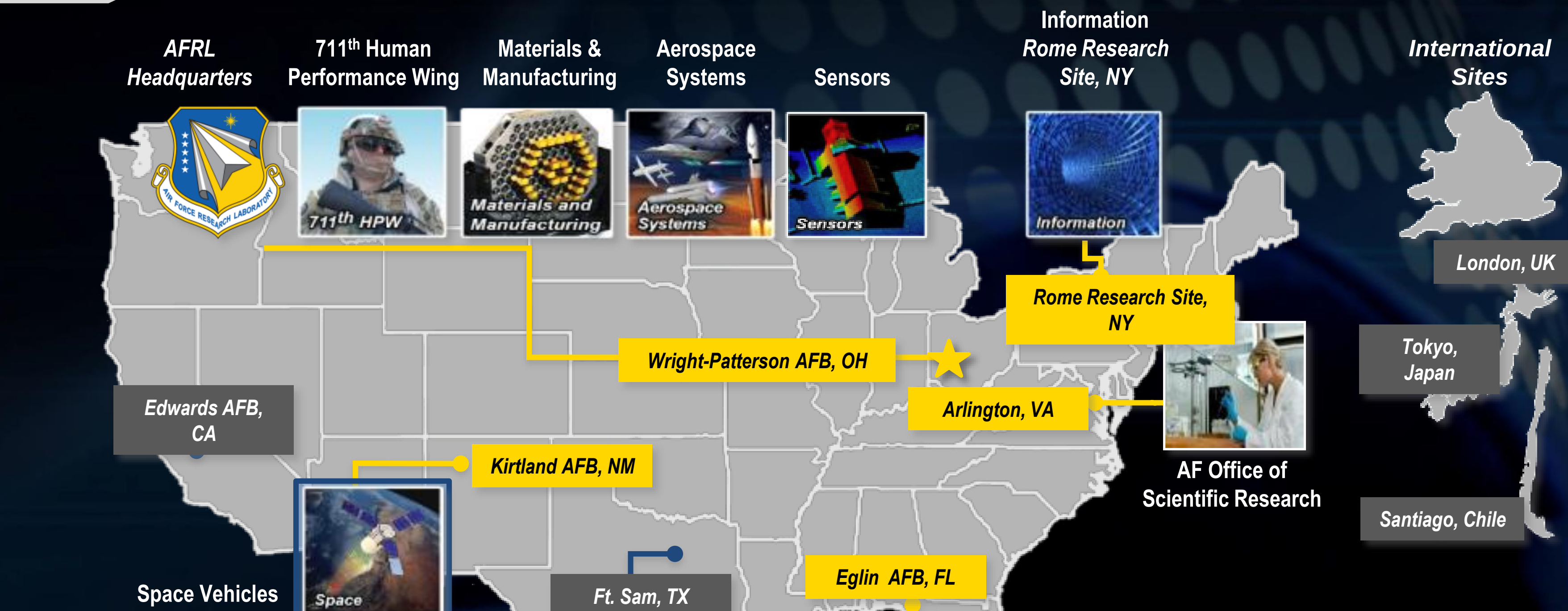
AFRL Mission

Lead the discovery, development, integration, and transition of affordable weapons technology, enabling the warfighter to win across all domains

[Better Buying Power 3.0:
Achieving Dominant Capabilities through Technical Excellence and Innovation]

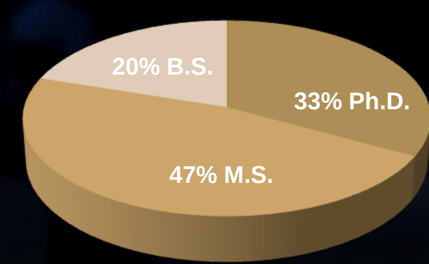
AFRL

AFRL Locations



	Employees	Civilian	Military
Total	5,827	79%	21%
S&Es	3,455	80%	20%

S&E Education



AFRL Enterprise

Commander
Maj Gen Robert McMurry

Executive Director
Mr. Douglas Ebersole

Vice Commander
Col Evan C. Dertien

Chief Technologist
Dr. Morley Stone

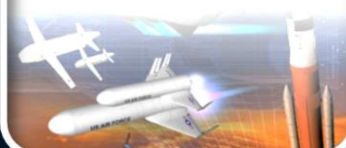
- **711th Human Performance**
- **AF Office of Scientific Research**
- **Aerospace Systems**
- **Directed Energy**
- **Information**
- **Materials and Manufacturing**
- **Munitions**
- **Sensors**
- **Space**

AFRL Weapons Related S&T

"The AFRL Weapons S&T Enterprise"

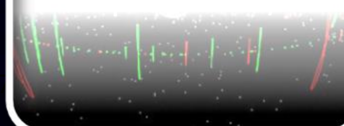
AF Office of Scientific Research
- Aero-structure power and control
- Physics and electronic
- Mathematics, Information, and bio-inspired sciences

Aerospace Systems
- High Speed propulsion
- Weapon propulsion
- UAV technologies
- Aerodynamic sciences



Directed Energy
- Laser weapons
- High Power Microwave Weapons
- DE Countermeasures for weapons
- KE/DE Integration

Information
- Weapon C2
- Weapon mission planning
- Weapon information backbone / architecture
- Weapon NISTR



Human Performance
- Weapon C2 / mission planning user interfaces
- Weapon buildup optimization
- Autonomy

Munitions
- Ordnance Sciences
- Fuze Technology
- Munitions AGN&C
- Terminal Seeker Sciences
- Munitions System Effects Science

Sensors
- Sensors
- Weapon integration into Airborne Sensing Layer
- Targeting ISR
- Long Range Combat ID

Space Vehicles
- Plug-and-Play architecture expertise
- Weapon BLOS comms
- Weapon integration of ISR data

Materials and Manufacturing
- Weapon materials
- Countermeasures hardening
- Weapon module connectors
- Weapon manufacturing optimization

AFRL

Why is Research Important?

"The first essential of air power necessary for our national security is… **Research**"

- General Henry "Hap" Arnold

"…innovation – fueled by intelligent, creative Airmen – will remain a key part of who we are and what we value as a service."

"Create the Future or it will be created for you"

- General Welsh, CSAF

AFRL

Turning Science Into Capability

Driven by Service Core Functions

Vectored by Air Force Strategy + S&T Vision/Horizons + Product Center Needs + MAJCOM Needs

6.1 Basic Research

6.2 Applied Research

6.3 Advanced Tech Demo

~ $5B

Science Knowledge → Technologies → Capability Concepts → Warfighter

Outputs:
New Technologies

Outputs:
Mature Technologies

Outputs:
Flagship Capability Concepts

25 Years | 10 Years | 5 Years | 1 Year

Initial Operating Capability Timeline

AFRL

Partnering with Industry & Academia

- **Effective partnership with industry is critical**
  - Academia often have the best understanding of the science and technologies
  - Industry will be the recipient of the science and technology transition
  - Work affordability in Science & Technology phase
- **Early, often, and active industry engagement is key**
- **However, must respect Intellectual Property and Organizational Conflict of Interest concerns**

AFRL/RW

The Munitions Directorate

RW Leadership

RW Chief Scientist
Dr David Lambert

Director
Col John Gloystein

Deputy Director
Joe Letsinger

RW Chief Engineer
Ms Anne Carstens

Senior IMA
Col Denise Edwards

Munitions Directorate Product Divisions

Ordnance
Mr Tim Tobik

Weapons Engagement
Mr Scott Teel

Strategic Planning & Demonstrations
Col James E Colebank

Financial Management
Ms Denise Wagner

Integration & Ops
Mr John Williams

Contracting
Ms Stacey Darhower

Safety Office
Lt Col Charles Tobia

MUNITIONS DIRECTORATE

AFRL

AFRL/RW Effects-Based Strategy

Fully *integrated weapons S&T portfolio* that exploits both the unique and complementary capabilities of *Kinetic and Directed Energy* systems in meeting the *needs of the US Air Force and the Joint Warfighter*

Must leverage the entire AFRL enterprise along with active industry partnerships!!

Weapon Trade Space Development

1 Warfighter Defines:
- Capability Gaps
- Threats
- Targets

2 AFRL/RW
- ID's Tech Enablers
- Conducts Trade Studies
- Matures Tech

5 New Capability

3 AFRL/RW & XZW Define:
- Weapon Attributes
- Capability Planning

4 Development Planning

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By Maturing Enabling Technologies Through

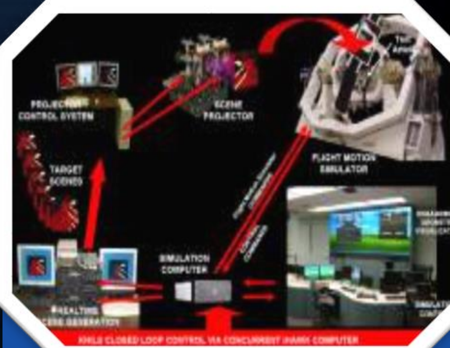
Core Technical Competencies (CTCs)

Ordnance Sciences

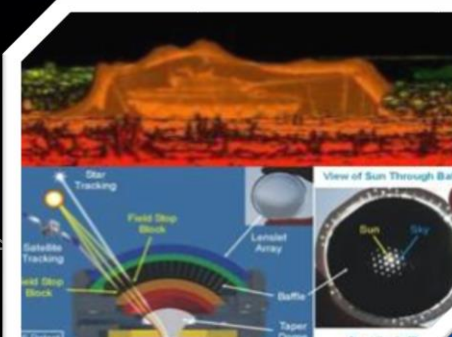
Munitions Aero, GN&C

An Integrating Directorate

Fuze Technologies



Munitions Systems Effects



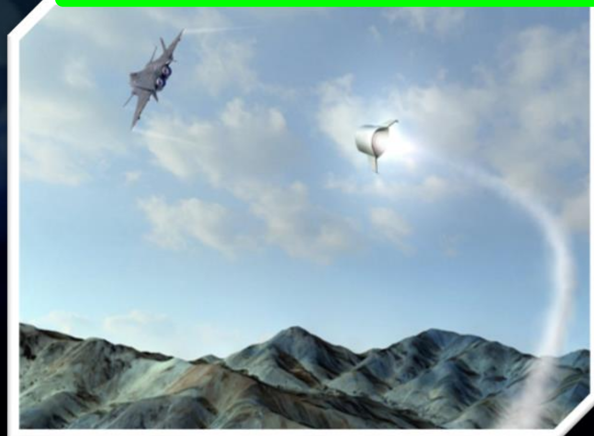
Terminal Seekers

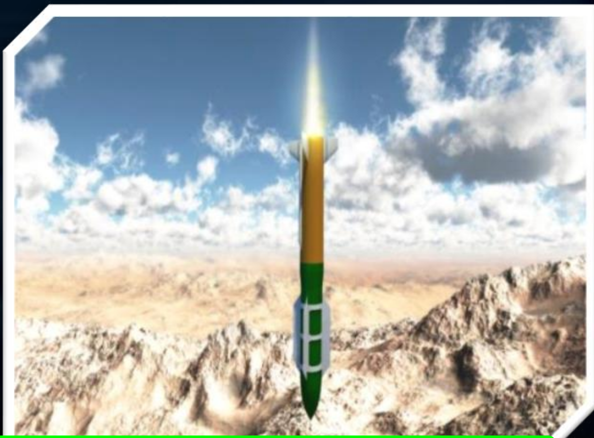
New Weapons Concepts Areas

(Capability Areas – Core Function Gaps)

Strategic Attack / Air Interdiction Tech

Air Superiority Missile Tech



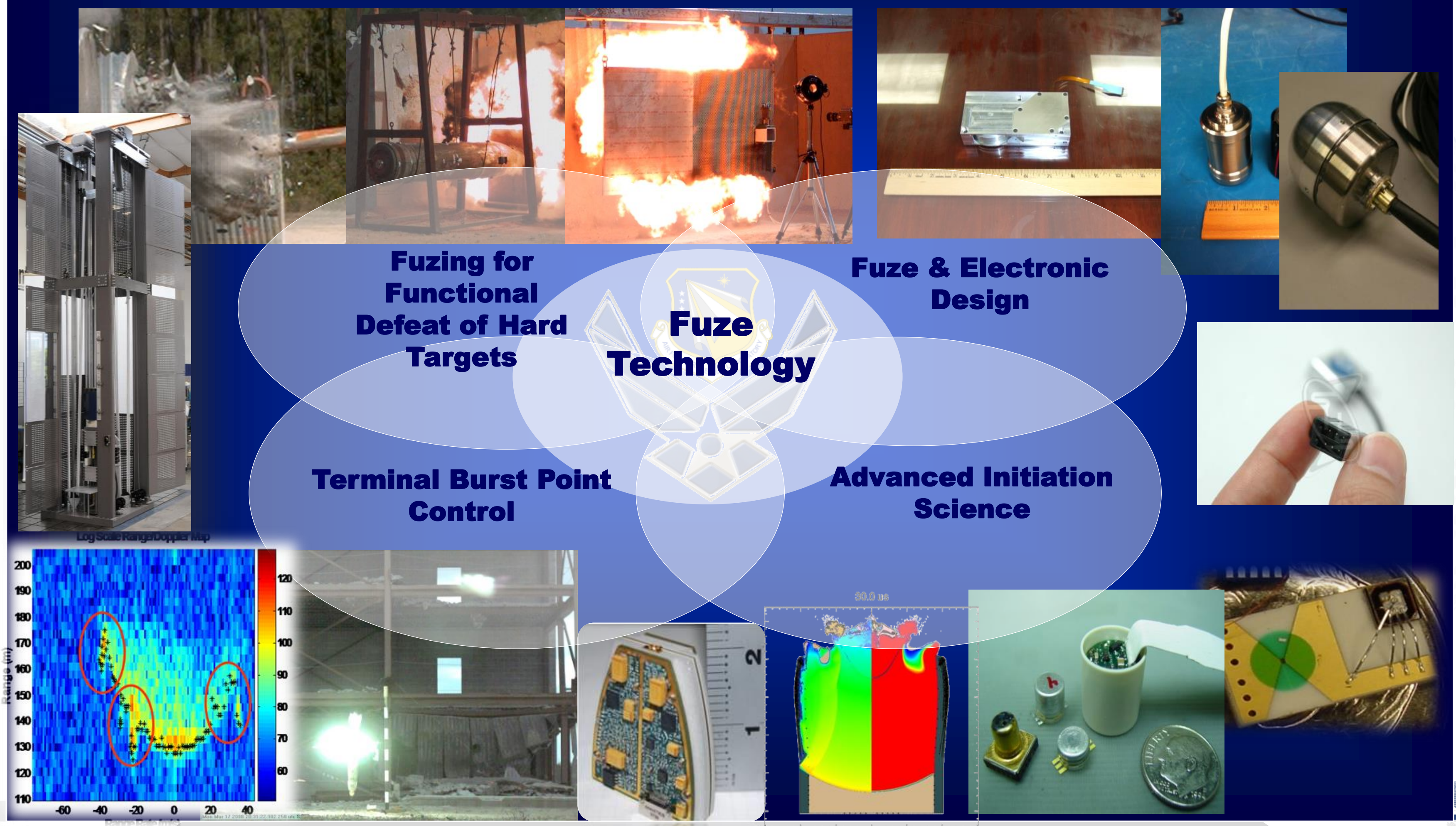


HDBT Defeat Tech

Close Air Support, Special Operations

Fuze Research Areas

Lead, Discover, Develop, Integrate, and Transition Science and Technology For Fuzing of Air-Delivered Munitions that Maximize Weapon Effectiveness



Distributed Embedded Fuze System

Presentations:

19318 - Proposed Fuze Safety Qualification Procedures for Distributed Embedded Fuzing Systems

19328 - Mechanical Survivability of Embedded Forward Assemblies in High-Pressure and Vibratory Environment

19303 – Mechanical Testing of Embedded Fuze Designs

19352 - Precision Initiation for Next-generation Engagements (PINE)

Issues/Risk:
- Void/Layer sensing capability in embedded fuzing may not be possible
- Research may not accurately characterize embedded environment
- Data recorders may not survive high-speed cannon tests

Internal/External:
Internal: RWMF, RWML, RWME, RWMW

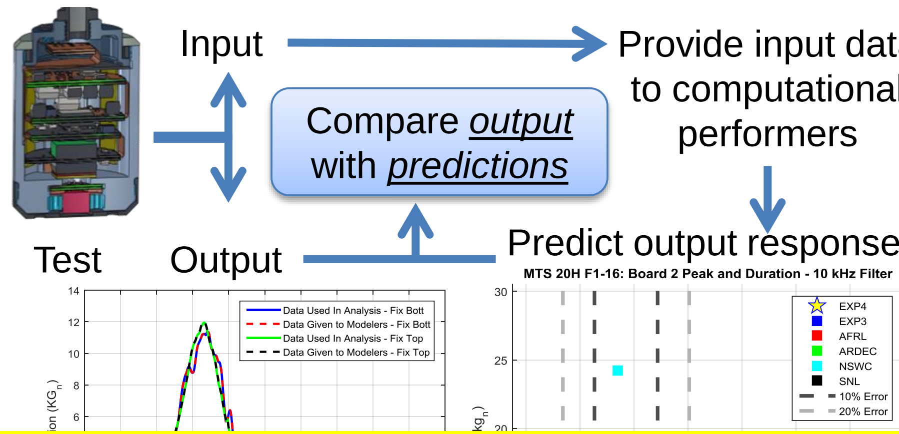
External: Sandia National Labs (SNL)
- National Security Campus (NSC)
- Armament Research Development & Engineering Center (ARDEC)
- Reynolds Systems Inc. (RSI)

TPM	Threshold	Objective	Current TRL
Survivability	100% mechanical function after 2500 fps penetration event	100% mechanical function after 4000 fps penetration event	4/shock testing prototype
Reliability	98% detonation under live-fire tests	100% detonation under live fire tests	3/Concept Defined
Accuracy	Detect void after 2-foot layer & clock accuracy within 98% of programming	Detect void after 6-inch layer & clock accuracy within 99.9% of programming	2/Concept Defined

12-G-041 (6.3) Fuze Modeling Grand Challenge

Description

- **Technology:** Determine (i.e. benchmark) capability of computational codes to accurately predict the response of fuze components when subjected to a high shock environment
- **Technical Approach:** Quantify the capabilities of a set of computational codes to predict the response of an instrumented fuze subjected to a known high shock input



Presentation:

19317 - Fuze Modeling Grand Challenge: Computational Comparisons

Technical Challenges:

- Ability to accurately test and measure the response of components in instrumented fuzes
- Developing specific parameters for assessing the accuracy of the model
- Repeatability of test method and data

Technical Metric of Success:

- Peak input acceleration within 10% of each other for VHG machine and drop tower tests conducted on instrumented fuze

Schedule	FY12	FY13	FY14	FY15	FY16	FY17
Develop Test Article						
Test Article 2 Predictions						
Test Article 3 Predictions						
Cannon Test Predictions						
Report Documenting Best Practices						

* Application of codes are at TRL 6

Focused Lethality Using Precision HOB

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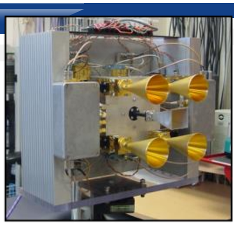
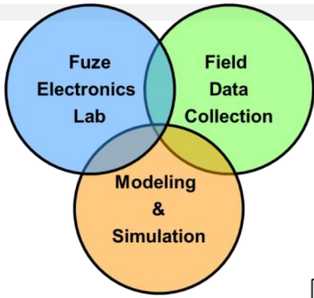
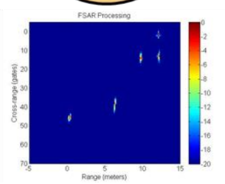
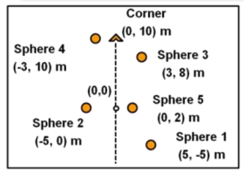
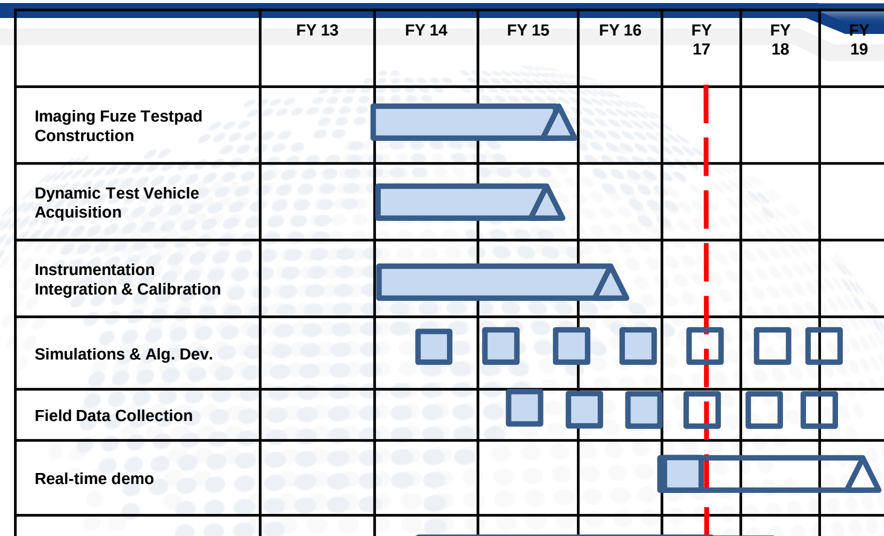
Advanced Fuze Sensor Algorithms











As of Date: 07302015

Objectives: **Investigate forward looking active imaging fuze**

Presentation:

19266 - Imaging fuze experimentation for weapon terminal burstpoint control

optimum fuzing for every weapon/target encounter

- Critical enabler for electrically aimed mass focused warheads

Issues/Risk:

- Algorithms have only been successfully evaluated with computer simulation
- Need field test data with truth to prove feasibility

Internal/External: In-house project / SBIR Phase II supporting (Technology Service Corp.)

- Target centroiding algorithms (follow-on in RWMF)

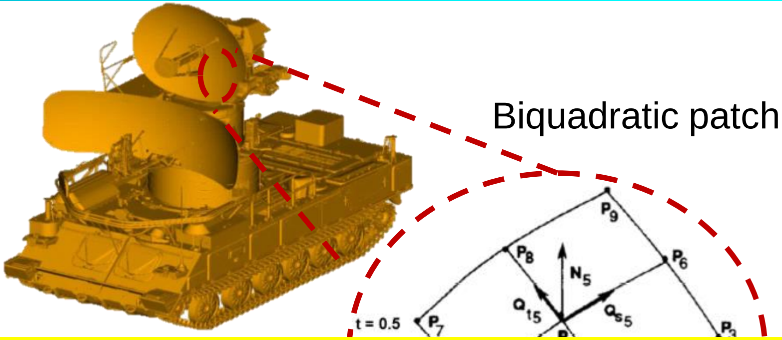
Technical Performance Measures

Metric	Threshold	Objective	Current TRL	Rationale
Range Focusing Uncertainty	<1 m	<0.5 m	3	Simulation
Angular Uncertainty	<4 degrees	< 2 degrees	3	Simulation
Convergence on Target Aimpoint	>25 m	>50 m	3	Simulation

16-G-013 (6.2) Maturation of Fuze Radar Simulation Software

Description

- **Technology** – Fast radar signature simulation tool for complex targets. Speed enables iterative design of fuze sensor algorithms.
- **Technical Approach** – Validate with field data, install and optimize on graphical processor unit (GPU) cluster.
-



Presentation:

19267 - Fast Synthetic Scene Generation for Fuze Sensor Development

Vol. 27, No. 5, (1991)

Technical Challenges/Metrics

Technical Challenge:

- Development of high-resolution non-faceted CAD models of complex targets to support rigorous experimental validation.
- Optimization of cluster code for improved GPU speedup.

Technical Metrics of Success:

- Imaged scatterer position error obtained after applying simulated data to fuze sensor algorithm (<4 degrees az & el, 1 m range).
- Speedup between GPU and central processing unit (CPU) computing (~5x)

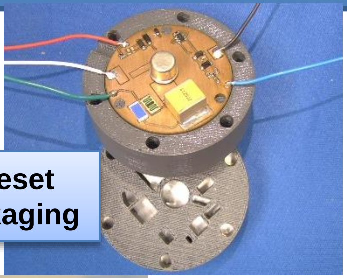
Schedule	FY15	FY16	FY17	FY18	FY19
SBIR enhancement work		3			
Expansion to GPU cluster					
CAD model creation					
Experimental validation					
Software update				5	

14-G-004 (6.2) Repackaging Penetrator Fireset Components for Enhanced Reliability and Survivability

Description

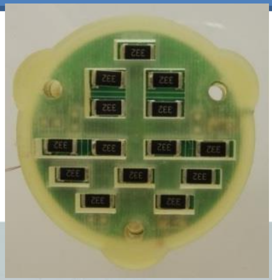
- **Technology:** Develop packaging technologies for a fuze fireset to improve the survivability and reliability during a high shock environment
- **Technical Approach:** Encapsulant-free design using Additive Manufacturing (AM) and low inductance part-on-part design architecture

Candidate Packaging Schemes



Fireset Packaging

Optimization of AM Fireset Supports



Presentation:

19368 - Shock Testing of 3D printed multi-material circuits

Technical Challenges:
- Functionality and high reliability in extreme shock environments

Technical Metrics of Success:
- Reduce the strain in an unpotted circuit board by an order of magnitude
- Maintain equivalent survivability of a state-of-the-art potted fire set utilizing AM techniques & materials

Schedule	FY14	FY15	FY16	FY17	FY18
Dsgn, Fab & Eval Repackaging Schemes	2				
Dsgn, Fab & Demo of HyperFireset					
Dsgn & Optimization of Printed Supports					
Syst Demo in High Shock Environment					4
Dsgn Rules and Recommendations					

Legacy of War-Winning Technology Development

Early Flight | Space Age | Modern Flight | Cyber Domain | Future