Vision Statement

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*
Tech Focus Area Core Technical Competencies (CTCs) ($310M FY14 TOA)

- Bio-Effects
- Basic Research
- Fusing
- Ordnance Sciences
- Laser Systems
- Air Vehicles/High Speed Systems
- Guidance
- High-Powered Electro-Magnetics
- Munitions Systems Effects Sciences
- Functional/Structural Materials

15% of FY14 TOA allocation:
- 20% Weapons
- 16% Munitions Systems Effects Sciences
- 11% Functional/Structural Materials
- 12% Munitions Systems Effects Sciences
- 6% High-Powered Electro-Magnetics
- 5% Laser Systems
- 6% Ordnance Sciences
- 5% Fusing
- 10% Basic Research
- 6% 5% Bio-Effects

DISTRIBUTION A. Approved for public release, distribution unlimited. (96TW-2013-0014)
Goals/Objectives

**Motivation**

- Develop power systems that involve materials at high energy density as well as plasma effects on combustion and control surfaces
- Discovery of novel, thermally robust materials and new techniques for characterizing, predicting and controlling thermal phenomena
- New theoretical and experimental approaches to advance macro and micro energetic systems

**Technical Approach/Ideas**

Fundamental science to support AF needs in multiple applications:

- Investigate new technology such as thermopower wave, that convert chemical energy to fuel cells
- Explore layered metallic systems for optimal synergy between magnetic, structural & superconductors
- Develop the mechanistic understanding of catalytic processes to activate small, gaseous inorganic molecules
- Developed new materials using carbon nanotubes and composites to create systems such as morphing
- Create new optical cavities to generate powerful laser beams

**Mission/Vision Statement**

**Mission:** We discover, shape, and champion basic science that profoundly impacts the future Air Force.

**Vision:** The U.S. Air Force dominates air, space, and cyber through revolutionary basic research.

**Goals/Objectives**

**Goals:** Revolutionary advances in nonequilibrium chemistry, nanotechnology, high power laser research as well as novel propulsion, production, storage, and utilization of energy.

**Objectives:** To develop novel energetic materials by integrating core disciplines of combustion, plasma dynamics, chemistry, hybrid simulation, structures and materials.

Federico Capasso at Harvard University demonstrated a new type of light beam that propagates without spreading outwards which will improve photonic devices.
Motivation

- Launch to lethality simulation capability including physics based, 6-DOF, mission, scene generation, and HWIL
- Accurate analysis limited by numerous tech challenges outlined in detailed CTC research plan
- Reduced risk in development

Technical Approach/Ideas

What are key technical ideas

- Mesoscale, molecular, and atomistic scale computational mechanics for lethality and survivability
- EO/IR/RF/Ladar scene projectors – high temp IR, wide FOV, IR LED, multi-spectral/hyper spectral projectors
- KE/DE integrated effects tools for analyses/weaponeering
- Synthetic scene generation tools – FPGA and massively parallel GPU’s, distributed, hyper spectral
- 6-DOF, mission, and campaign level simulations for performance analysis and concept development

Mission/Vision Statement

- **Mission** - Provide the knowledge and M&S capabilities to support the design, test, assessment, and transition of advanced munition system and subsystem technologies
- **Vision** – Be the preeminent munition launch-to-lethality assessment group reducing the time, cost, and risk associated with development and transition of munition components and concepts

Goals/Objectives

- Advanced physical modeling, higher fidelity, and faster running
- More accurate physical modeling of advanced technology and environments
- M&S tools and analyses

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**Tasks**

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Weapons TFA
MSES CTC

Near-Term 2013-2015

- Precision small weapon blast
- Combined blast+fragment loading
- Multi-phase blast effects models
- Functional defeat
- Validation of structural response
- Propagation through failed openings

Mid-Term 2016-2020

- Coupling molecular mechanics models into hydrocodes
- Testing and model development of functional defeat methodologies
- Modeling synergistic effects
  - KE / DE
  - Blast/frag
- Collective Defeat

Far-Term 2021-2025

- High resolution physics models into fast running lethality codes
- Complete warhead system simulation at quantum physics level

Higher Lethality Warheads, Energy Coupling and Robust M&S
Weapons TFA
Fuze Technology CTC (FY 14 $15.5M)

Mission/Vision Statement

- **Mission**: discover, develop, integrate, and transition fuze technology that maximizes weapon lethality, survivability, and safety for air-delivered munitions
- **Vision**: To work the technologies today that provide the safest, most reliable, and most lethal fuzing systems of tomorrow’s air-delivered weapons.

Goals/Objectives

- **Goal**: maximize weapon lethality, survivability, and safety for air-delivered munitions through revolutionary advances in high shock physics of materials, energetic material initiation sciences, terminal target detection and initiation control
- **Objectives**: Reliable fuze in hypervelocity penetrators, lethal coupling of electrical/mechanical/chemical energy, Adaptive active imaging, novel power generation technique

Motivation

- Current fuzing technology evolution of WWII concepts
- Limits flexibility in weapon design and forces complexity with reduced reliability
- Research in revolutionary fuze technology architectures, techniques, materials, and components allows for systematic approach to novel weapon design resulting in reduced size, decreased costs, and increased performance

Technical Approach/Ideas

- Distributed Embedded Fuze System - DEFS
  - Simplifies Ordnance design
  - Increases reliability
  - Decreases cost of acquisition and logistics
- Miniaturized Sub-millimeter wave proximity fuzeing
  - Form factor compatible with both full-size and miniature munitions
  - Advanced Algorithms for sub-meter accuracy
- Sub-nanosecond interferometric initiation diagnostics
Weapons TFA
Fuze Technology CTC

Near-Term 2013-2015
- Survivability protocol for legacy fuzing applications
- Hardened post-impact fuze module
- Precision Height of Burst (HOB)

Mid-Term 2016-2020
- Validation (test, M&S) of fuze environment
- Distributed fuzing

Far-Term 2021-2025
- Non-inertial target detection
- Tactical imaging for mass-focused directional ordnance

Enhanced Survivable Fuzes
### Mission/Vision Statement

- **Mission:** Discover, develop, integrate and transition leading-edge science and technology in ordnance systems for ensured effects required by the AF mission.
- **Vision:** US air power supremacy through ordnance systems having precision outcome; every time and at every application.

### Goals/Objectives

- **Goal:** Provide the optimal response of conventional weapons through core competencies in ordnance materials, understanding energy effects and coupling to the target, and leading new energetic formulations for tomorrow’s warfighter requirements.
- **Objectives:** Selectable and tailored response of the weapon-target engagement, safe but robust lethality for explosive ordnance, highly survivable in the extreme environments of impact and weapon carriage.

### Motivation

- Today’s weapon system must be highly flexible across a wide-range of applications.
- Targets of tomorrow are harder, deeper and more greatly protected against strike effects.
- Autonomous weapons evolving today require selectable and responsive kill mechanisms.
- Integrated weapon effects for non-linear increases in complex and functional kill are now realizable.
- Space & volume constraints require multi-functional materials with structure and energy release.

### Technical Approach/Ideas

- **Reactive Material Structures**
  - Strength and density of steel with 4X energy of explosive/steel penetrating systems
- **Survivable explosives for tomorrow’s 5th/6th Gen**
  - High thermal and vibration of explosives in hypersonic platforms
  - Shock survivable in high speed penetrators
- **Multi-phase blast and optimal target coupling**
- **Sound, international lead in specific Ordnance Sciences tech base and Discovery for tomorrow’s capabilities**
Weapons TFA
Ordnance Sciences CTC

**Near-Term 2013-2015**

- Survivable warhead design with novel nose and tail fuzewells
- Low collateral damage and miniature warheads
- Material properties under extreme loading conditions
- Eglin Steel - ES-1V

**Mid-Term 2016-2020**

- Materials and structures for extreme environment survivability
- Adaptive response for increased lethality and low collateral damage
- Optimized multifunctional warhead technologies, e.g., reactive structures

**Far-Term 2021-2025**

- Non-kinetic energy solutions for target defeat
- Directional, multimode, tailorable output warheads
- Joint/multi-service integrations

**HDBT Defeat & Small Wpns**

**Enhanced Lethality – Increased Loadout**
Mission/Vision Statement

- Research & Develop Non-Kinetic Technologies to enable electronic attack
- Develop technologies for HPEM weapons across the full span of legacy, new, and future air platforms

Goals/Objectives

- Develop HPEM sources and components that provide significant size reductions with enhanced power/energy
- Seeking knowledge in HPEM sources, materials and components
- Deliver laboratory breadboard systems and employment concepts for transition to the warfighter

Motivation

- CHAMP JCTD demonstrated the operational utility of HPM weapons
  - Engage multiple targets with no collateral damage
- Legacy, new, and future air platforms require further size reductions with increased effectiveness ranges
- Enable HPEM weapons for both rapid acquisition and for future air platforms

Technical Approach/Ideas

- Exploit nanomaterials and metamaterials for high power microwave sources and systems
- Exploit advances in energy storage and power generation to build compact HPM/DE power systems
- Advance computational capabilities to address multi-scale simulation requirements for HPEM system design
- Develop predictive effects models to simulate HPM effects across multiple systems
HPEM S&T Strategy
Capabilities / Deliverables (FY14 $40M)

Near-Term  FY13-18
Next Gen Airborne Counter Electronics Demo with operationally relevant ranges
• Compact flexible HPM sources and pulsed power
• Characterize complex effects, model effectiveness
• Design, develop, test and assess a multi-shot and multi-target HPM cruise missile
• Agile waveform sources, compact pulsed power
• Transition to acquisition

Mid-Term  FY19-24
Deliver enhanced Counter Electronic Effects from operational platform
• Transition technology & knowledge to acquisition, industry & warfighter
• Optimize waveforms for enhanced effectiveness
• Improve source efficiency
• Reduce system size / weight
• Develop BDA technologies

Far-Term  FY25-30
Deliver Adaptive, Long-Range Counter Electronic Effects, Smart Waveform Cyber/EW Attack
• Smart waveform HPM subsystems to greatly reduce weight / volume on small re-useable platforms
  - Decreased SWAP HPM sources
  - Cooperative target engagement real time BDA
  - Waveform control for optimized effects; validation of target vulnerability assessments

Transition Increasingly Capable, Game-Changing CE Weapon Technologies
Weapons
Laser CTC (FY 14 $62M)

Mission/Vision Statement
- Develop and Integrate Laser Systems to meet the MAJCOM gaps and S&T needs
  - Emphasize solutions for an A2/AD environment

Goals/Objectives
- Demonstrator Laser Weapon Systems
  - Objective: Integrate first-gen electric laser (HELLADS)/beam control and demonstrate lethality
- Ground-based Self-defense (Multi-Role Transportable Laser)/ Retire S&T by Integrating a fiber laser system into a platform

Motivation
- Develop solutions to address the A2/Ad environment
- Improve SA and CID, and Defeat air and ground targets
- Develop a ground based defensive capability for area/unit defense

Technical Approach/Ideas
- Integrate/demonstrate planning capability concept to retire fiber laser integration risks with specific emphasis on future airborne systems.
  - End-to-end modeling
  - Lethality demonstration
- Integrate/demonstrate Pod mounted planning capability concept to increase the TRL level of an airborne countermeasure system
  - Perform ground demonstration tests
  - Perform airborne demonstration tests
Laser Systems Strategy
Capabilities / Deliverables (FY14 $55M)

Near-Term  FY13-17
• Demo lethal effects with integrated 1st gen HELADS/LS technology
• Multi-Role Transportable Laser (MRTL)

Mid-Term  FY18-22
• Airborne POD mounted flight test on Legacy Aircraft
• Proactive Self-Defense with NIR and MWIR laser capability
• Fully-predictive Laser System models, validated by integrated flight tests

Far-Term  FY23-28
• Efficient, light-weight HEL with conformal aperture beam delivery for Future Air Dominance A/C
• Flight qualified turret

Move Toward the Full Range of Tactical Platforms
**Mission/Vision Statement**

- Develop directed energy and electro-optical technologies to improve the nation’s space superiority capability

**Goals/Objectives**

- Optimize the performance of the baselined operational SSA architecture
- Cost-effectively augment the architecture
- Create affordable trade-space for eventual expansion of the architecture

**Motivation**

- Space domain has become significantly more congested, contested, and competitive
- Space is an integral part of the fabric of our nation’s infrastructure supporting both peacetime and wartime capabilities
- Directed energy and electro-optical technologies offer unique ability to find, fix, track, and characterize space objects anytime, anywhere

**Technical Approach/Ideas**

- Detect, track, and ID small, dim objects in GEO and GEO-transfer orbits
- Timely characterization techniques to identify adversary threats and capabilities
- Threat warning and assessment concepts to enable attribution and allow for response time
- New data integration and exploitation capability for the JSpOC Mission System POR
- Dynamic and automated sensor tasking to optimally tip/cue SSA assets
- Evaluate space system resiliency and protection options to include operational & material solutions
DEEOSS S&T Strategy Capabilities / Deliverables

**Near-Term**

**Forensic**
- Space Catalog development
  - Deliver new tools to JSPOC Operators
  - Processing for 150K+ Object Catalog
  - Rapid UCT (uncorrelated track) resolution

- Use of EO imagery & signatures to understand satellite characteristics
  - Extend high-resolution imaging of LEO objects to daylight & full-dark for improved timeliness
  - Link unresolved EO signature data to EEs through physical/functional models

- Sodium Laser Guidestar
  - Image dim objects and satellites in full-dark
  - Detect small, dim objects next to larger objects at GEO

**Mid-Term**

**Predictive**
- Tactical Persistent Monitoring
  - Provide GEO Threat awareness using ground-based optical telescopes
  - Dynamically task sensors to provide persistent surveillance and maintain custody from launch through insertion

- Demonstrate High-Res GEO imaging
  - ISAL – Inverse Synthetic Aperture LIDAR

- Apply predictive signature modeling to enable threat Indications and Warnings (I&W) for SSA
  - Deliver JSpOC applications to integrate EO signatures with non-EO data sources
  - Improve characterization and timely change detection of threat objects

- Protection and Resiliency
  - Threat modeling and options for Comm & Navigation in the A2/AD environment

**Far-Term**

**Operationally Responsive**
- Exquisite characterization and modeling to enable predictive awareness and threat mitigation
  - Support DCS operations through Intel Prep of the Battlefield (IPB) for Space

- Integrated and timely knowledge
  - Allow implementation of Courses of Action (COAs) in response to space events, threats, and opportunities
  - Ability for our space warfighter to operate inside adversaries’ OODA Loop – Operational Responsiveness

- Bottom Line - Situational Dominance for Space Control Operations

Techniques & Tools to Increase Speed & Fidelity of Knowledge for SSA
Summary

• AFRL is poised to provide technologies for future weapon systems
• AFRL relies heavily on collaboration with industry, academia and other national labs

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