Directed Energy S&T Challenges Overview

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Develop, integrate, and transition science and technology for directed energy to include high power microwaves, lasers, adaptive optics, imaging, and effects to assure the preeminence of the United States in air and space.
What is directed energy?
AFRL/Directed Energy Directorate

Electromagnetic Spectrum

- High Power Radio Frequency (RF)
- High Power Microwaves (HPM)
- High Energy Lasers (HEL)
What is directed energy?
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- **Precision Engagement**
  - Selective targeting measured by the inch
  - Rapid re-targeting in real time

- **Speed-of-Light Delivery**
  - Immediate attack with global reach
  - Surprise element for enemy confusion

- **Controlled Effects**
  - Minimum collateral damage
  - Graduated effects from deny to destroy

- **Logistical Advantage**
  - Seamless awareness of battlefield and space
  - Deep magazine without shelf-life or stockpile issues
Customers and Products
AFRL/Directed Energy Directorate

Near Term: Transition to Acquisition Community and Industry


Rapid Prototyping

Non-Lethal Weapons

Active Denial

Aircraft Self-Protection

Aircraft Countermeasures

Adaptive Optics
Customers and Products
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Mid Term: Existing Customers and Demonstration Partners
Advanced (Concept) Technology Demonstration (ACTD and ATD)

Near Term: Transition to Acquisition Community and Industry


Laser Imaging
Advanced Beam Control
Tactical Lasers
Counter IED
Ballistic Missile Defense
Customers and Products
AFRL/Directed Energy Directorate

- Long Term: Strategic Planning of cross directorate integrated systems of systems development
- Mid Term: Existing Customers and Demonstration Partners
  Advanced (Concept) Technology Demonstrations (ACTD and ATD)
- Near Term: Transition to Acquisition Community and Industry

Game Changing Technologies

Space Control - Counter Electronics – Precision Engagement – Long Range Strike – Force Protection
Focused Long Term Challenges
(FLTCs derived from S&T Vision)

ANTICIPATE

Space

Air

Cyber

AF²T²EA⁴

ANYTHING, ANYTIME, ANYWHERE
Focused Long Term Challenges
AFRL Investment Strategy

Delivering the Air Force S&T Vision through Leadership, Discovery, Innovation, and Integration.

1. Anticipatory Command, Control and Intelligence (C2I)
2. Unprecedented Proactive Surveillance and Reconnaissance (S&R)
3. Dominant Difficult Surface Target Engagement/Defeat
4. Persistent and Responsive Precision Engagement
5. Assured Operations in High Threat Environments
6. Dominant Offensive Cyber Engagement
7. On-demand Theater Force Projection, Anywhere
8. Affordable Mission Generation and Sustainment
DE Problem Statements
AFRL/Directed Energy Directorate

- FLTC-2 Unprecedented Proactive Surveillance & Reconnaissance
  - Assure All-Object Space Situational Awareness
  - Deliver On-demand, Lethal Effects to Difficult Targets with Ultra Precision
  - Engage Adversaries with Non-Lethal Force

- FLTC-3 Dominant Difficult Surface Target Engagement/Defeat
  - Globally Deliver DE and Non-Lethal Effects
  - Detect and Defeat Threats Through Active Defenses
  - Deliver Counter Electronics Effects

- FLTC-4 Persistent & Responsive Precision Engagement

- FLTC-5 Assured Operations in High Threat Environments

- FLTC-6 Dominant Offensive Cyber Engagement

Vision | Problem Statements | Tech Challenges | Approaches
Proactively Find, Fix, and Track Anything, Anytime, Anywhere with Agile and Immediate C4ISR

- Enable High Performance Networks for Assured C2 and Sensing
- Persistently Deliver Fused Multi-Source S&R for Total Battlespace Awareness
- Assure Closed-Loop C2ISR Sensing and Processing (anticipatory)
- Generate Wide-Area, Global Access, Detection and Tracking
- Deliver High-Volume, Super Resolution Imagery of Anywhere, Anytime
- Assure All-Object Space Situational Awareness
FLTC #2 Unprecedented Proactive Surveillance & Reconnaissance (S&R)

Assure All-Object Space Situational Awareness (SSA)

Objective: Detect/track all space objects at various altitudes

SSA Technology
Space Surveillance Metrics and Images
Optics for Atmospheric Compensation
# FLTC #2 Unprecedented Proactive Surveillance & Reconnaissance (S&R)

**Assure All-Object Space Situational Awareness (SSA)**

*Objective:* Develop technology in resolvable and non-resolvable characterization

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<td>Adaptive Optics Image…</td>
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**Adaptive Optics and Image Post Processing**

enables identification of deep space and dim objects
Assure All-Object Space Situational Awareness

**Objective:** Refine large aperture optical beam control technologies to provide improved tracking, imaging and dim object detection

- Capture real time, exquisite characterizations of satellites
- Detect micro-satellites within narrow field to include detection and discrimination
- Extend hours and object list for high bandwidth tracking
- Improve beam control capabilities for laser propagation applications
- Develop more efficient signature analysis for satellite identification and states
Assure All-Object Space Situational Awareness

**Objective:** Perform physical and functional analysis of satellites

- Analyze phenomena effects on the function/operation of subsystems and the entire satellite
- Perform analysis for potential directed energy (DE) threats
- Integrate and automate engineering data, analysis process
- Provide support to military and space communities
FLTC #3 Dominant Difficult Surface Target Engagement/Defeat

Detect, Tag, Track, Identify, Target Adversaries, IEDs, CBRNE in Congested or Concealed Environments and Create Desired Effects

- Find, ID, Assure-Tracking and Engage Individuals & IEDs
- Locate, ID, Engage and Neutralize CBRNE
- F2T2 Difficult Targets Including Complex Urban and Difficult Terrains
- Rapidly Deliver Scalable Kinetic & Non-Kinetic Effects to Difficult Targets
- Deliver On-Demand, Lethal Effects to Difficult Targets with Ultra Precision
- Engage Adversaries with Non-Lethal Force
FLTC #3 Dominant Difficult Surface Target Engagement/Defeat

Deliver On-Demand, Lethal Effects to Difficult Targets with Ultra Precision

Objective: Deliver lethal effects to a range of tactical targets in challenging environments and engagement scenarios

- Expand speed-of-light offensive and defensive capabilities
- Maintain precise aimpoint
- Obtain scaleable effects
- Supply deep magazine
- Provide minimal collateral damage
FLTC #3 Dominant Difficult Surface Target Engagement/Defeat

Deliver On-Demand, Lethal Effects to Difficult Targets with Ultra Precision

**Objective:** Provide high energy laser systems to enable ultra-precise lethal attacks on tactical targets

- Operate in highly dynamic environment
- Enable precision engagement at long distant ranges
- Minimize laser power requirements
- Meet stringent platform constraints
- Mitigate aero-optics distortion
- Provide system of systems laser testing
FLTC #3 Dominant Difficult Surface Target Engagement/Defeat

Engage Adversaries with Non-Lethal Force

Objective: Advance millimeter wave source and antenna system technologies to enable robust non-lethal counter personnel options

- Self-protect platform
- Clear lines of communication
- Deny access
- Provide urban air support
- Assist in personnel recovery
- Protect assets (troops, convoys, embassies, airfields, bases, etc)
- Support special operations’ efforts
FLTC #4 Persistent & Responsive Precision Engagement

Maneuver Through Anti-Access/Area Denied Environments to Deliver Effects Rapidly and/or Persistently

- Globally Deliver Directed Energy and Non-kinetic Effects
- Globally Deliver Full Spectrum of Kinetic Effects
- Globally Deliver Selected Effects for Time Sensitive Targets
- Covertly Globally Deliver Autonomous, Unattended Sensor Payloads
Objective: Provide Speed-of-Light awareness, communications, engagements, and assessments of anything, anywhere, anytime

- Look over the horizon
- Deliver scaleable force projection
- Uplink to a cooperative network
- Provide geostationary high energy laser in the sky
- Augment mission of forward fighting troops
- Increase stand-off range
FLTC #5 Assured Operations in High Threat Environments

Achieve Mission Objectives with Impunity Against Full Spectrum Threats, from Anti-Access IADS to Cyber

- Anticipate and Avoid Threats Through Stealth and Deception
- Detect and Defeat Threats Through Active Defenses
- Survive the Attack Through Passive and Adaptive Protection
- Recover from Threat Effects
FLTC #5 Assured Operations in High Threat Environments

Detect and Defeat Threats through Active Defenses

Objective: Fuse directed energy capabilities to detect, avoid, repel and survive attacks on land, sea, air and space

iMAGiNE

A Directed Energy Shield
FLTC #5 Assured Operations in High Threat Environments

**Objective:** Fuse directed energy capabilities to detect, avoid, repel and survive attacks on land, sea, air and space
FLTC #5 Assured Operations in High Threat Environments

**Detect and Defeat Threats through Active Defenses**

*Objective:* Fuse directed energy capabilities to detect, avoid, repel and survive attacks on land, sea, air and space.

- Layer a protection systems (fixed and mobile)
- Protect perimeters and high value assets
- Detect enemy activity beyond operational range thresholds
- Control crowds/separate insurgents
- Disrupt electronic systems
- Neutralize IEDs at safe distances
- Engage escort planes equipped with countermeasure weapons
- Defeat threats with conventional, HEL and HPM weaponry

Increase survivability of troops
FLTC #6  Dominant Offensive Cyber Engagement

Conduct full spectrum offensive cyber/info ops against military, leadership, and infrastructure

- Access Adversary’s Cyber/Info Systems Anywhere, Anytime
- Operate with Stealth and Persistence in Cyber
- Generate Robust Cyber Intelligence (CYBINT)
- Deliver Integrated D5 Information Operations Effects
- Deliver Counter Electronics Effects
FLTC #6 Dominant Offensive Cyber Engagement

Deliver Counter Electronics Effects

Objective: Disrupt adversaries’ critical military and infrastructure electronic and communication equipment with little to no collateral damage

- Disrupt communications
- Tailor for multiple attack paths
- Deliver to wide-area non-lethal coverage of urban areas with swarming UAVs
- Attack critical infrastructure, leadership, and CBRNE targets
- Identify electronic signatures to feed intelligence preparation of the battlespace (IPB) and battle damage assessments (BDA)
- Deliver low collateral damage through glide bomb fly-bys
Technology Challenges
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- High Energy Lasers
- High Power Microwaves
- Space Situational Awareness
- Adaptive Optics and Imaging
- Millimeter Waves
- Relay Mirrors
Bridge to the Warfighter
AFRL/Directed Energy Directorate

Acquisition Community
National Defense Industry
AFRL/DE Laboratory

Warfighter
Directed Energy

• Provides robust capabilities to the warfighter
• Offers integrated applications ready to field now
• Future DE paradigms
  – Deliver global reach on demand
  – Transform the way we engage our adversaries

DE has the Power to Change the face of military conflict.