



# ***Directed Energy S&T Challenges Overview***



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# Mission

## AFRL/Directed Energy Directorate



**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?

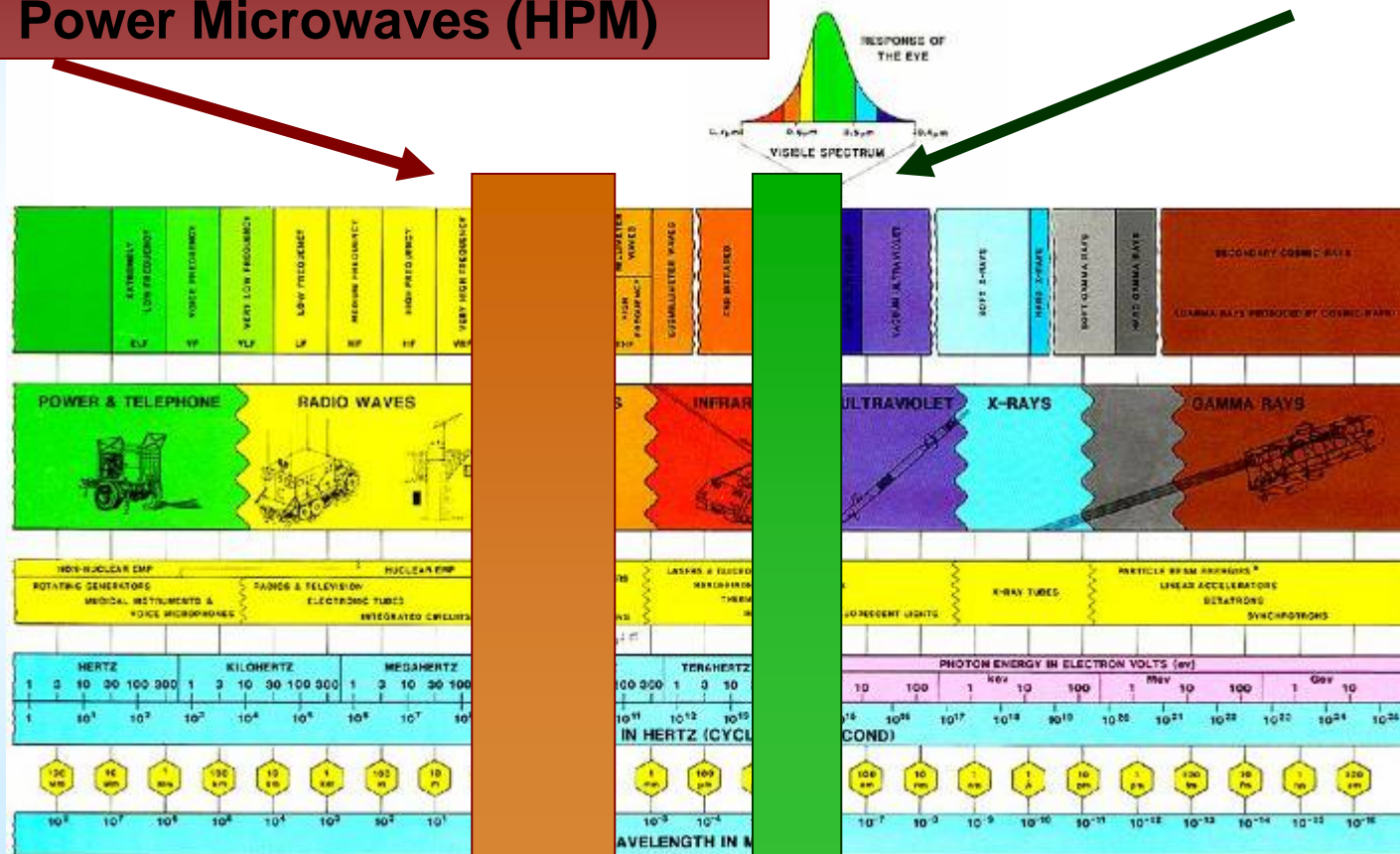
## AFRL/Directed Energy Directorate



### Electromagnetic Spectrum

High Power Radio Frequency (RF)  
High Power Microwaves (HPM)

High Energy Lasers (HEL)





# What is directed energy?

## AFRL/Directed Energy Directorate



- ***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**

|       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Today | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|



**Rapid Prototyping**



**Non-Lethal Weapons**



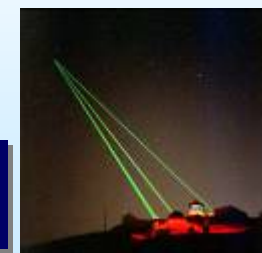
**Aircraft Self-Protection**



**Active Denial**



**Aircraft Countermeasures**



**Adaptive Optics**





# Customers and Products

## AFRL/Directed Energy Directorate



**Mid Term: Existing Customers and Demonstration Partners  
Advanced (Concept) Technology Demonstration (ACTD and ATD)**



**Near Term: Transition to Acquisition Community and Industry**

|       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
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**Laser Imaging**



**Advanced Beam Control**



**Tactical Lasers**



**Ballistic Missile Defense**



**Counter IED**



# 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**

|       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
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## *Game Changing Technologies*

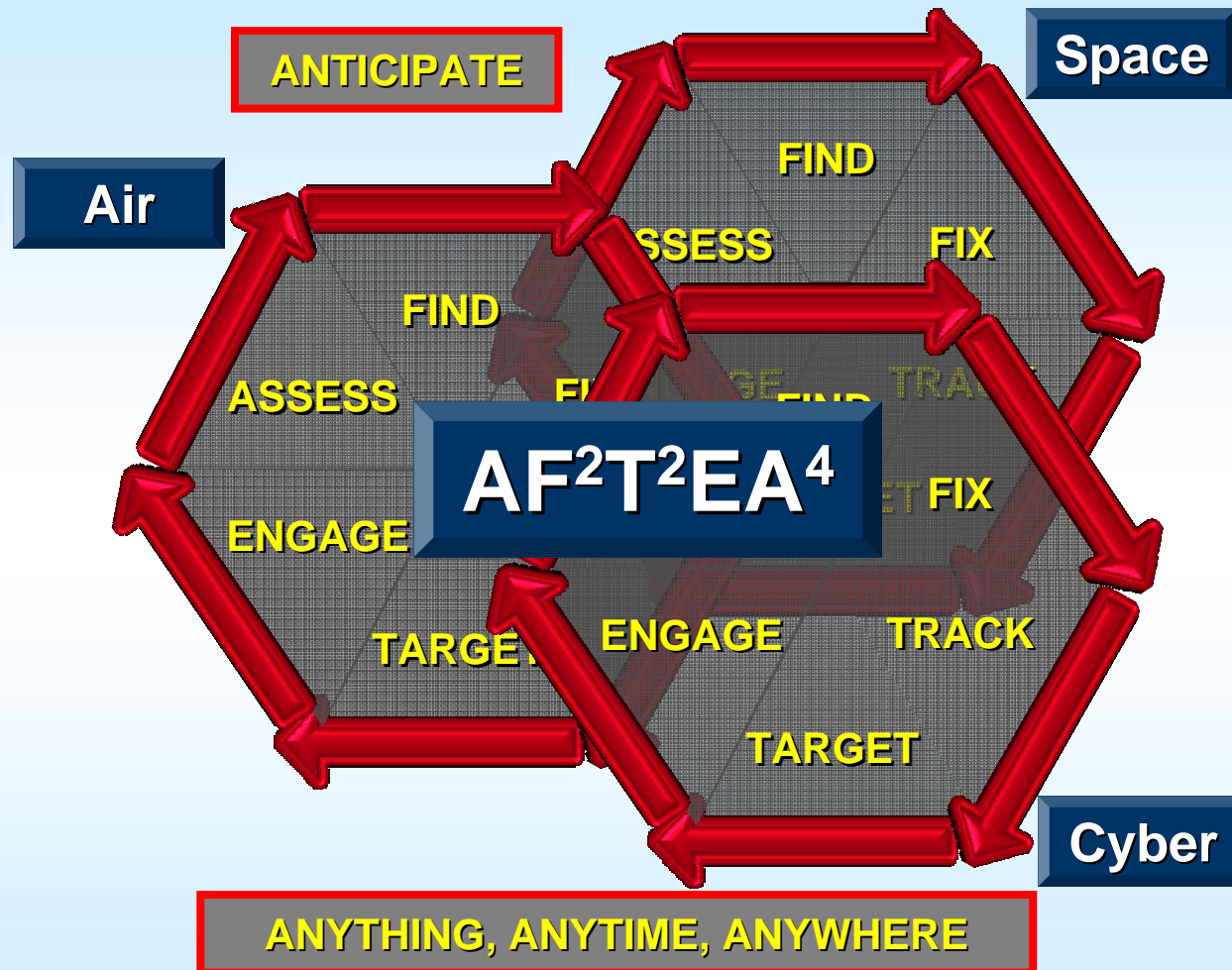


***Space Control - Counter Electronics – Precision Engagement – Long Range Strike – Force Protection***



# Focused Long Term Challenges

(FLTCs derived from S&T Vision)







# 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**

**FLTC-3 Dominant Difficult Surface Target Engagement/Defeat**

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

**Engage Adversaries with Non-Lethal Force**

**FLTC-4 Persistent & Responsive Precision Engagement**

**Globally Deliver DE and Non-Lethal Effects**

**FLTC-5 Assured Operations in High Threat Environments**

**Detect and Defeat Threats Through Active Defenses**

**FLTC-6 Dominant Offensive Cyber Engagement**

**Deliver Counter Electronics Effects**

*Vision*

*Problem Statements*

*Tech Challenges*

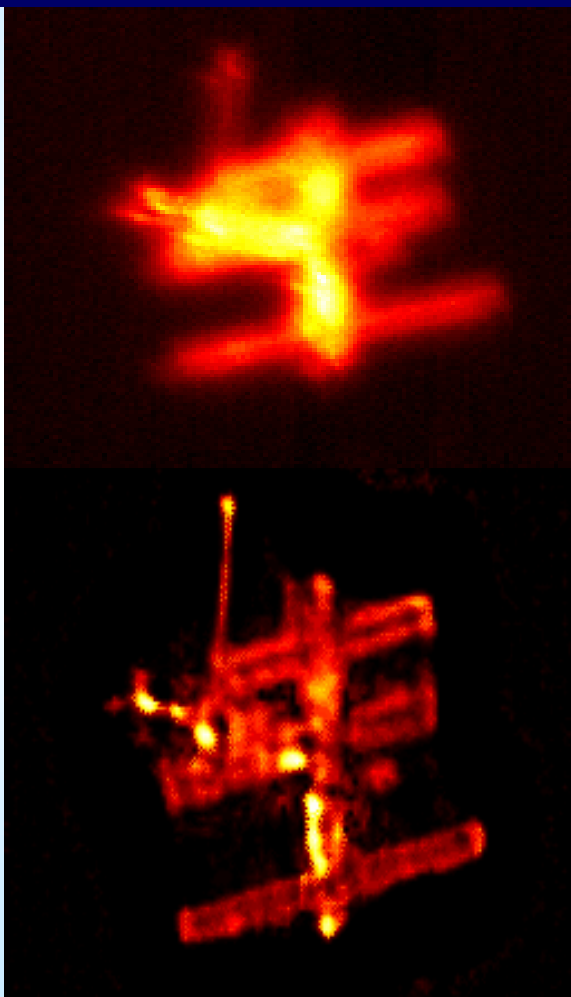
*Approaches*



## FLTC #2 Unprecedented Proactive Surveillance & Reconnaissance (S&R)



### 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**

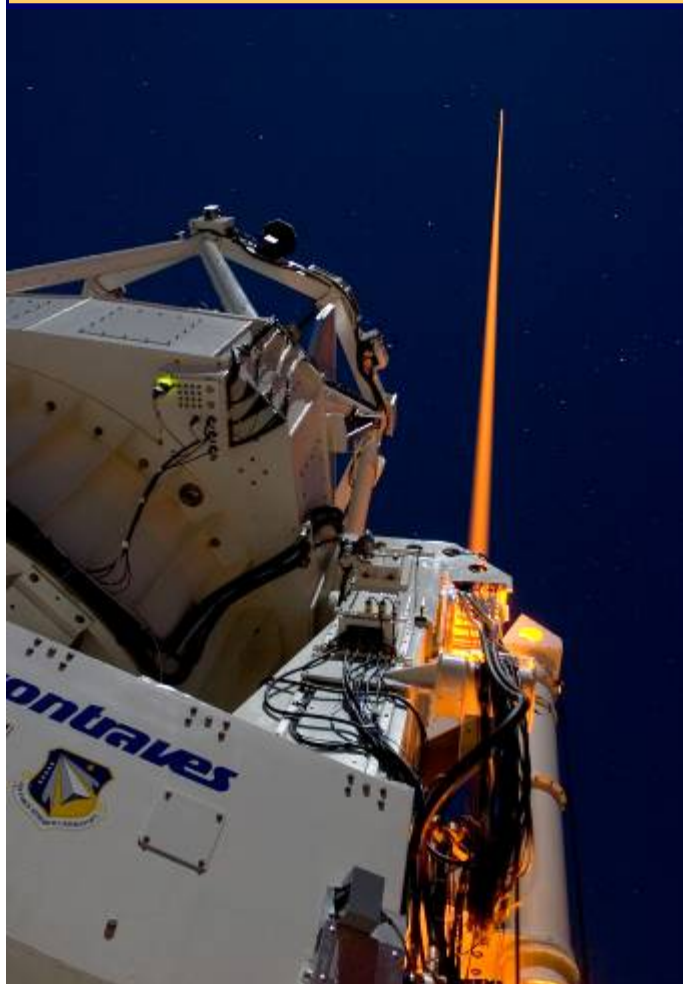


# FLTC #2 Unprecedented Proactive Surveillance & Reconnaissance (S&R)

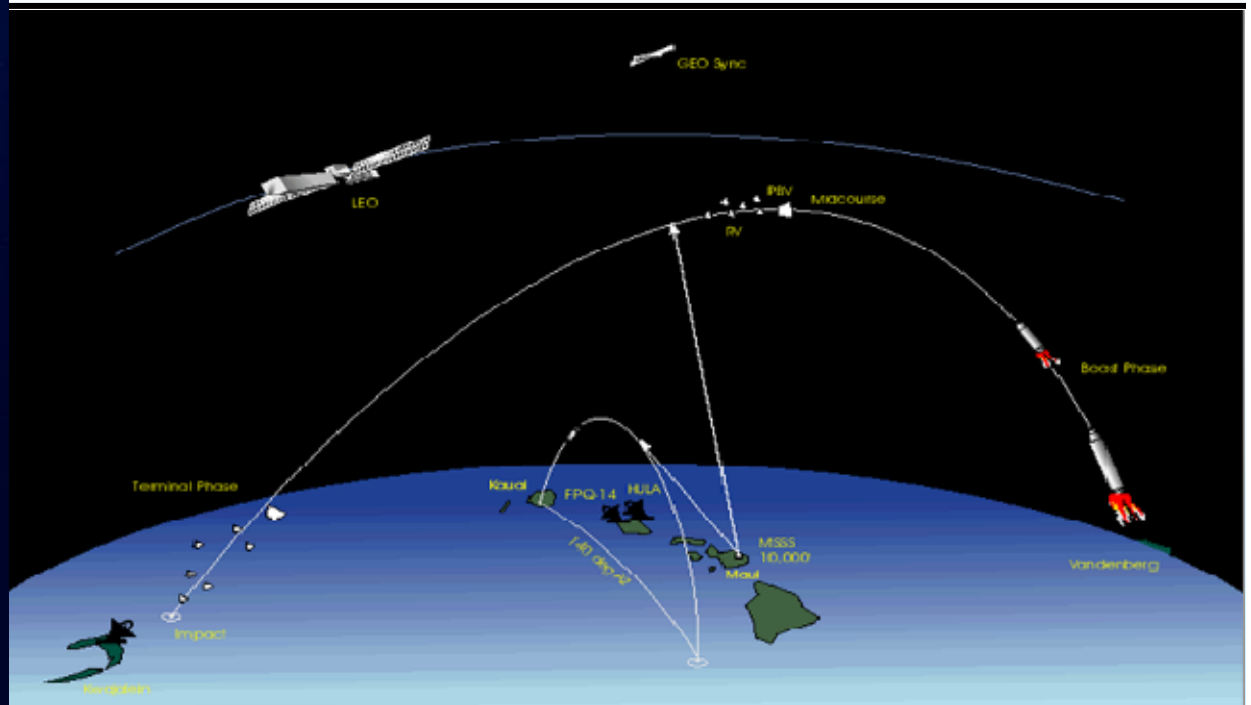


## Assure All-Object Space Situational Awareness (SSA)

*Objective:* Detect/track all space objects at various altitudes



*SSA Technology*  
*Space Surveillance Metrics and Images*  
*Optics for Atmospheric Compensation*





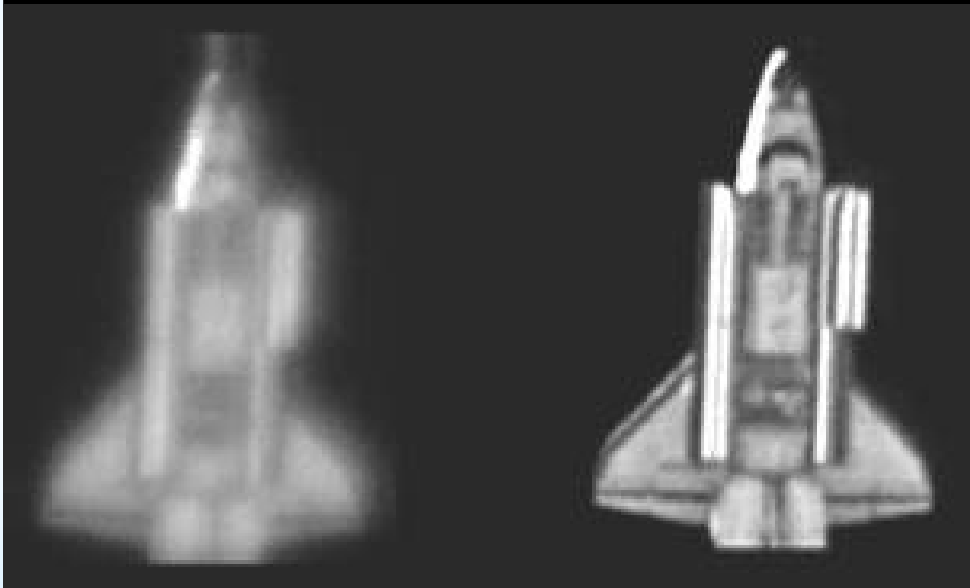
# FLTC #2 Unprecedented Proactive Surveillance & Reconnaissance (S&R)



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

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

**Space Shuttle**



Adaptive Optics  
Image...

...with  
Post Processing

***Adaptive Optics  
and  
Image Post  
Processing  
enables  
identification of  
deep space  
and dim objects***





# FLTC #2 Unprecedented Proactive Surveillance & Reconnaissance (S&R)



## 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

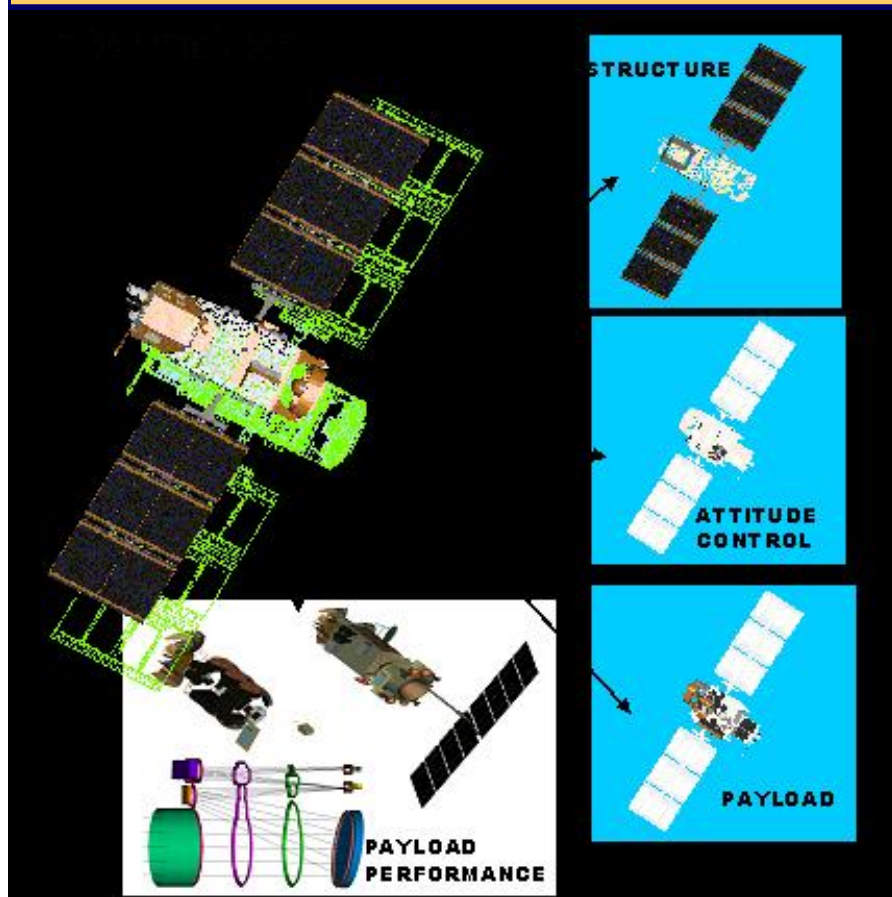


# FLTC #2 Unprecedented Proactive Surveillance & Reconnaissance (S&R)



## 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



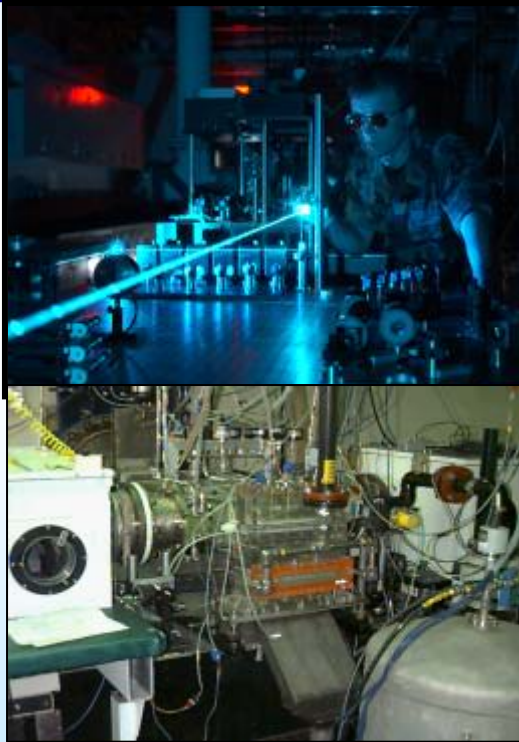


# FLTC #3 Dominant Difficult Surface Target Engagement/Defeat



## 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**



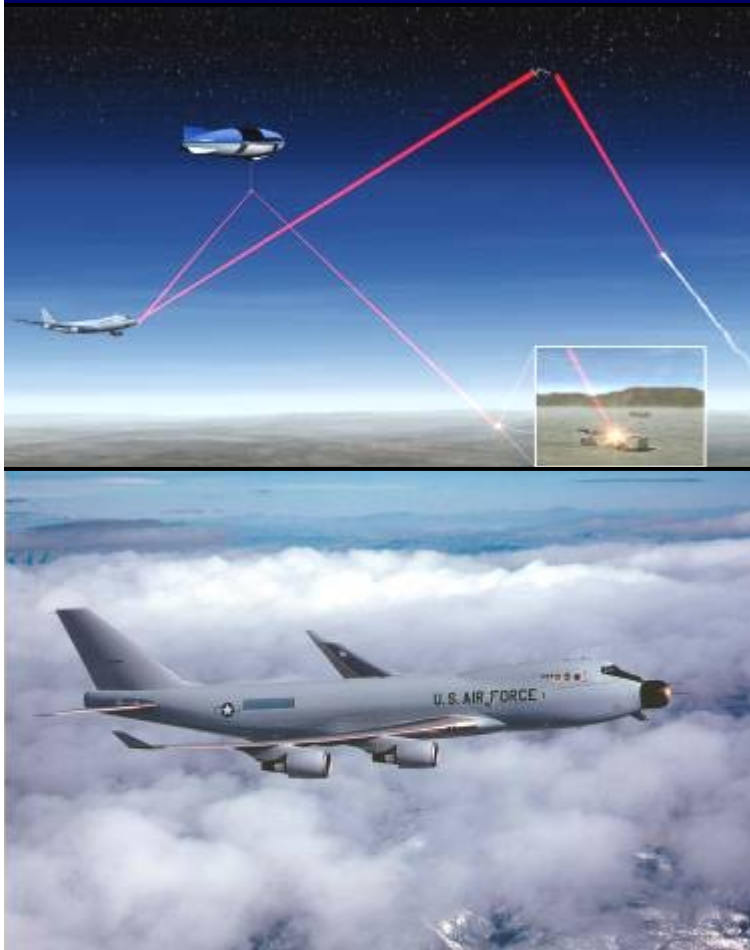
- Self-protect platform
- Clear lines of communication
- Deny access
- Provide urban air support
- Assist in personnel recovery
- Protect assets (troops, convoys, embassies, airfields, bases, etc)
- Support special operations' efforts



# 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

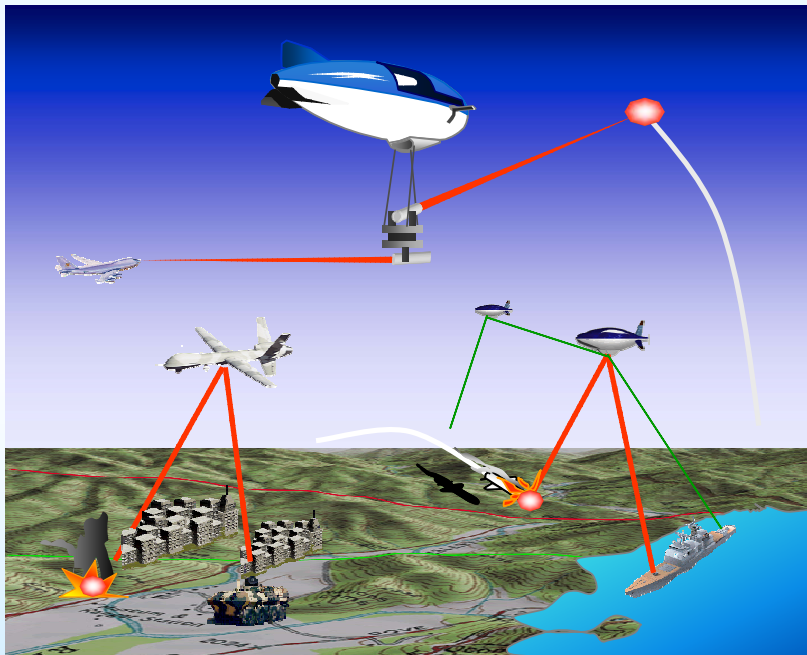


# FLTC #4 Persistent & Responsive Precision Engagement



## Globally Deliver Directed Energy and Non-Kinetic Effects

*Objective:* Provide Speed-of-Light awareness, communications, engagements, and assessments of anything, anywhere, anytime



- Look over the horizon
- Deliver scalable 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



## 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



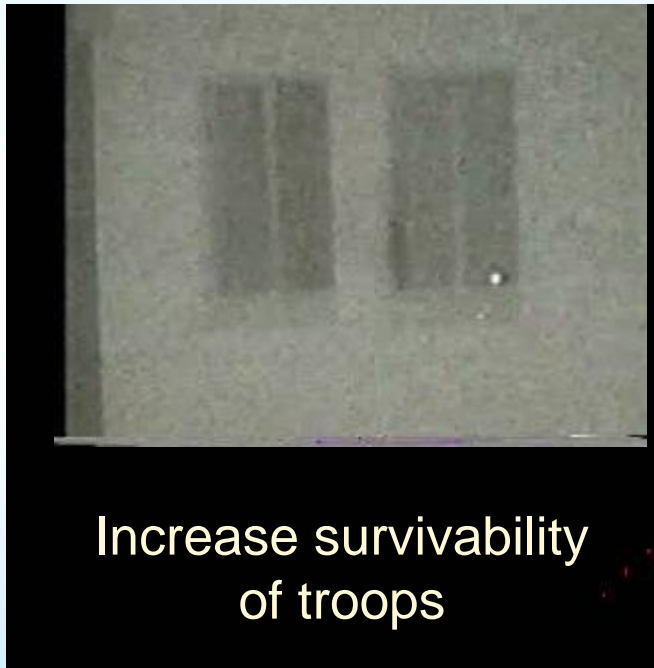


# FLTC #5 Assured Operations in High Threat Environments



## 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



Increase survivability  
of troops

- 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



# 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

## AFRL/Directed Energy Directorate



- **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



## ***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.***



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