Directed Energy and Base Defense

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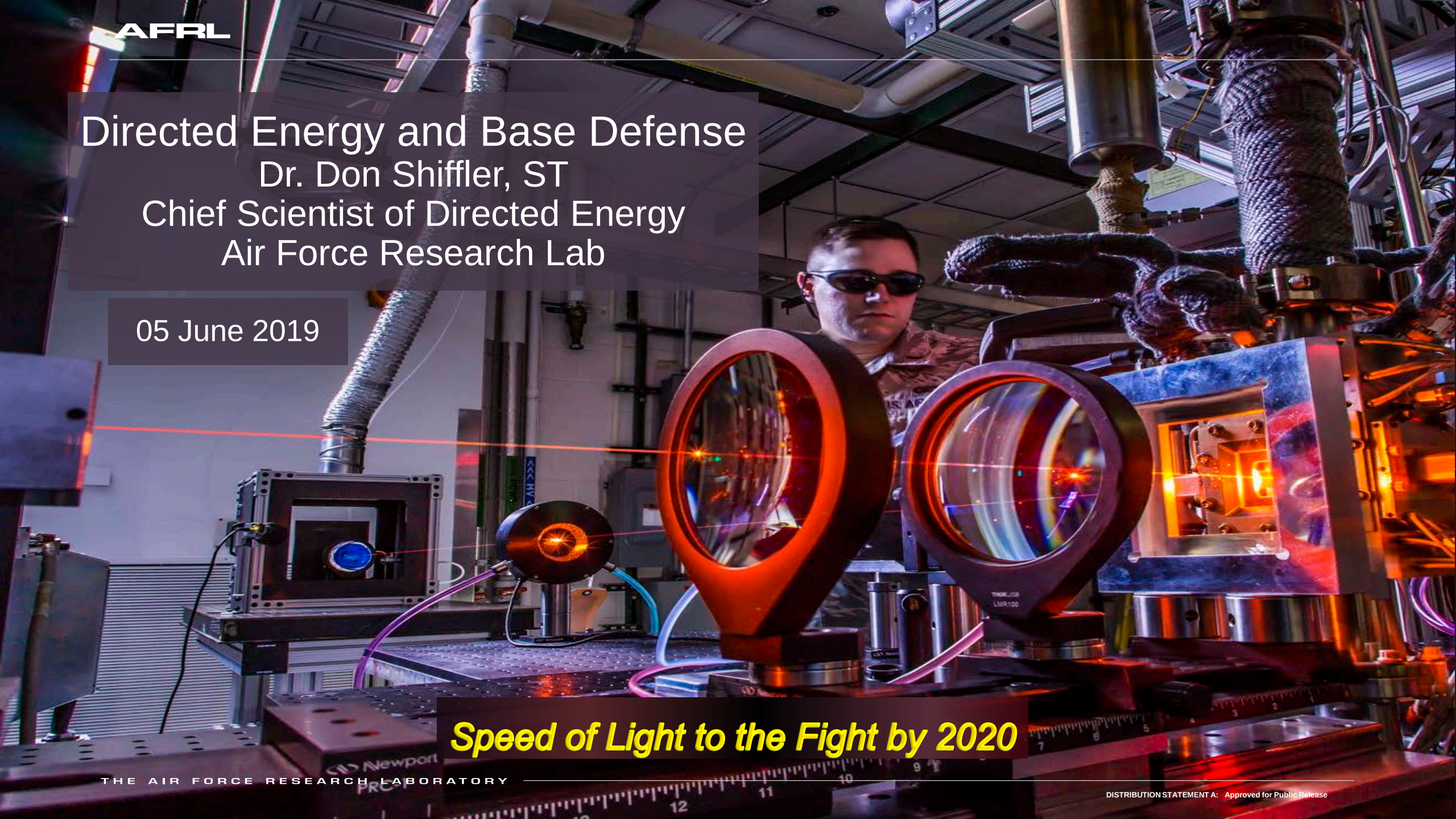
Air Force Research Lab

05 June 2019



Outline

- **Why Directed Energy?**
- **What are the Strategic Drivers for our S&T?**
- **Lasers for Aircraft Self-Protect**
- **High Power Microwaves for Base Defense**

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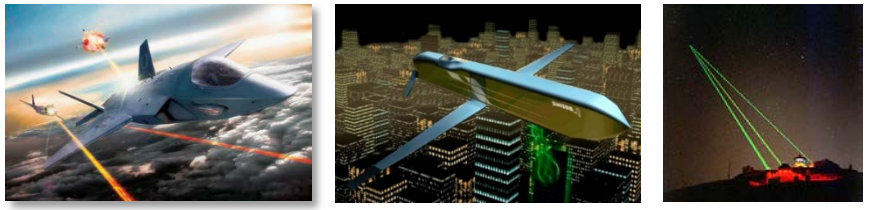
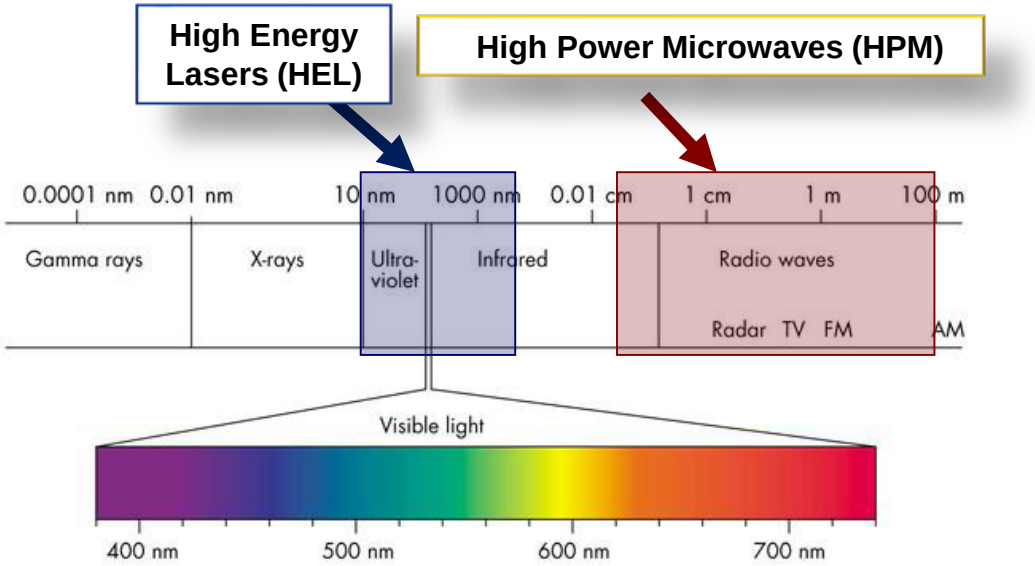
Why Directed Energy (DE)?

DE is a beam of concentrated electromagnetic energy

- Speed-of-Light Delivery
- Precision Engagement
- Controlled/Scalable Effects
- Logistical Advantage
- Low Cost per Shot





DE offers unique effects & benefits to the Warfighter

Why Directed Energy (DE)?

DE is a beam of concentrated electromagnetic energy

- Speed-of-Light Delivery
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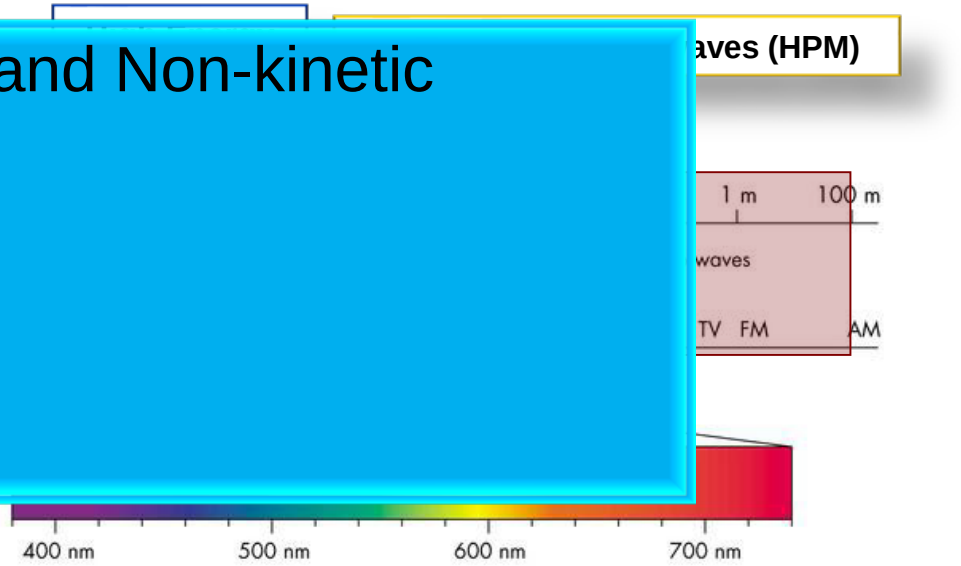
- Force multiplier: Kinetic and Non-kinetic synergies are imperative!
- Not a cure for everything
- Not 100% effective



DE offers unique effects & benefits to the Warfighter

AFRL Directed Energy

Mission

Leading the discovery, development, and integration of affordable *directed energy* warfighting technologies for our air, space, and cyberspace force.

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Great Power Competition

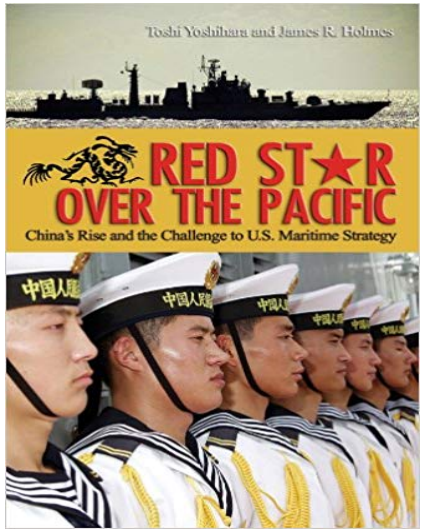
Out-gunned and Out-sticked in the Western Pacific

THE DEBATE

China's New Missiles in the Spratlys May be a Turning Point

There is no longer any reason for China to acknowledge the diplomatic fig leaf of Xi Jinping's "militarization" assurance.

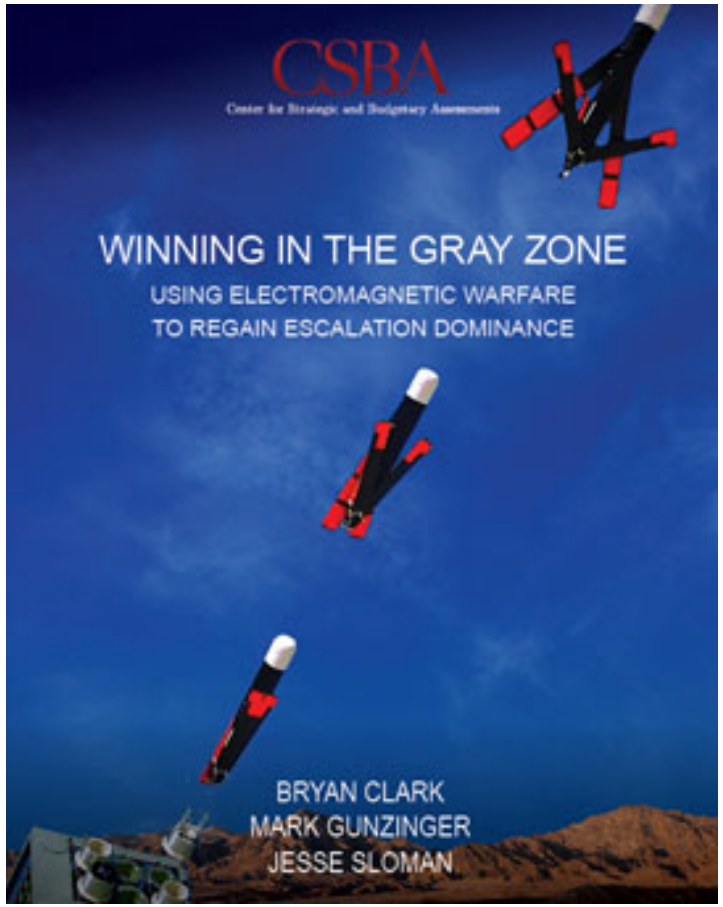
By Steven Stashwick
June 14, 2018



Warfare in the Gray Zone

Incapable of fighting gray zone warfare

- Rise of China and Resurgent Russia



Outlook • Perspective

Russia is advancing on Ukraine again — and Ukraine isn't going quietly

President Petro Poroshenko tells the Post how he wants the war to end.

Most Re

Study→ Experiment →Prototype

Class 1 & 2 UAS are being used as precision guided munitions to target heavily guarded areas.

DJI Phantom 4

A *single* $1,000 UAV can hold an *entire F-22 squadron* at risk

10JAN2018

Russian Base in Syria

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Self-Protect High Energy Laser Demonstrator (SHiELD) ATD

Description

- SHiELD was commissioned by the Air Combat Command Applied Technology Council as an Advanced Technology Demonstration (ATD) in 2015.
- SHiELD's mission is to integrate a high energy laser and beam control system into a singular pod that will be mounted to a tactical platform in order to shoot down an incoming threat.
- Success of this ATD will indicate a TRL of 6 for High Energy Laser Technology for the Aircraft-Self protect mission

Purpose

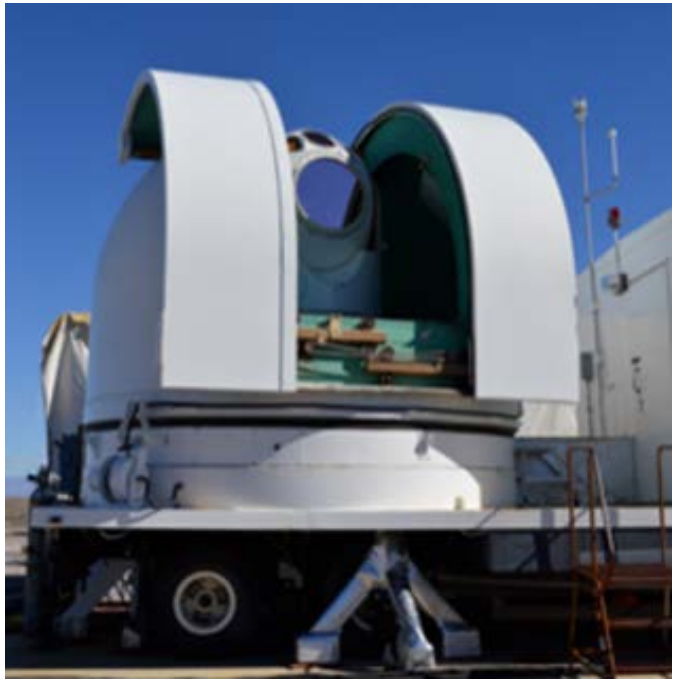
- Improve future aircraft survivability by providing self-protect capability from High Energy Lasers
- Retire Science and Technology risks associated with integrating high energy lasers on tactical platforms
- Demonstrate maturity of integrated laser systems in a complex flight environment

Approach

- Beam Control Testing: Demonstrating aero-effects mitigation
  - Acquisition, tracking, and pointing performance on threats
  - Characterization of aero-effects to develop concepts to expand operational envelop
  - Improved performance through aero-effects mitigation
- High Power Target Testing: High power system demonstrating performance in flight against threats
  - Aircraft & high power laser system compatibility & concept of employment
  - Provides initial data for reliability, maintainability, availability
  - Anchors system models with flight data
  - Informs follow-on science and technology investments

Recent Success – MFC Testing

- **Major Test Milestone accomplished April 2019:**
  - **Shoot-down of several in-flight missiles at White Sands Missile Range, NM**
  - **Employed DLWS (Demonstrator Laser Weapons System) to serve as a surrogate High Energy Laser (HEL) System for SHiELD Engagements**
    - Note: SHiELD will be much smaller and lighter, as well as ruggedized for an airborne environment.
  - **Necessary intermediary step for SHiELD System**
    - Demonstrates failure mechanisms of relevant threats



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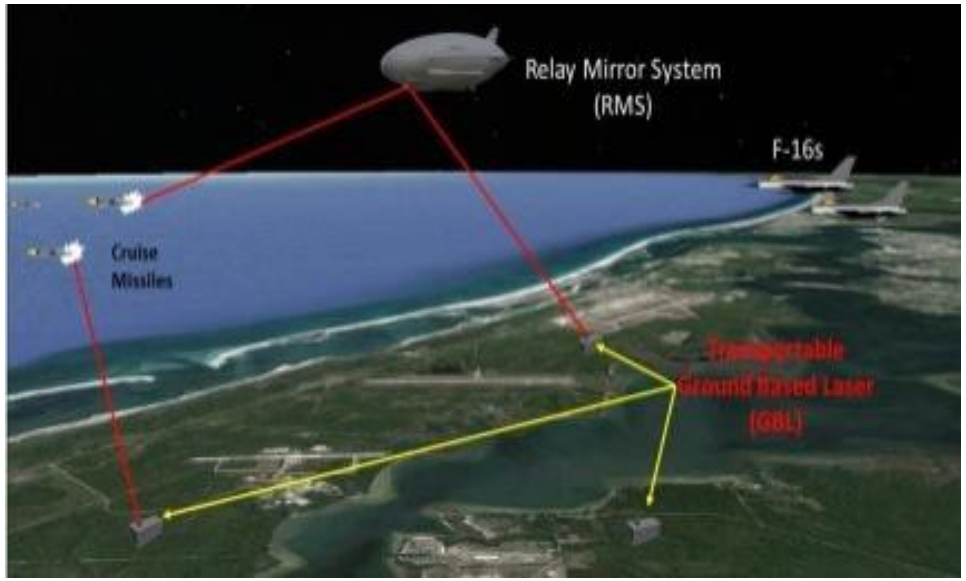
Hybrid Defense of Restricted Airspace (HyDRA I/II) Addresses Airbase Defense Challenges



- **GOAL:** Perform systems, engagement, and mission-level Military Utility (style) Assessment (MUA) of the HyDRA system of systems.
- **CAPABILITY:** Cost-effectively defend bases, strategic targets, etc. against attacks by UAS, CM & RAM considering weather.
- **STUDY HYPOTHESIS:** Hybrid Kinetic & Directed Energy weapon & sensor solutions maximize system capability

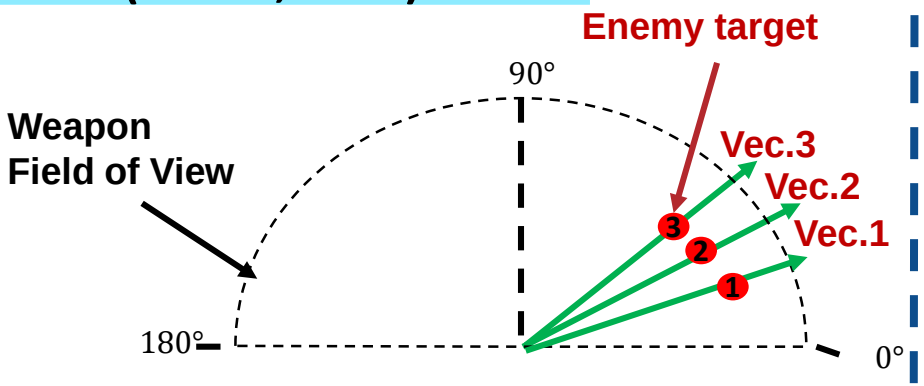
The HyDRA team delivered to AFLCMC/HBU (Force Protection SPO) trade space brief for DE C-sUAS

– Full trade space includes sensors, HEL, and HPM options to address the C-sUAS JUON by early 2019

HyDRA I Resulted in fielding of positive ID prototype in NRC

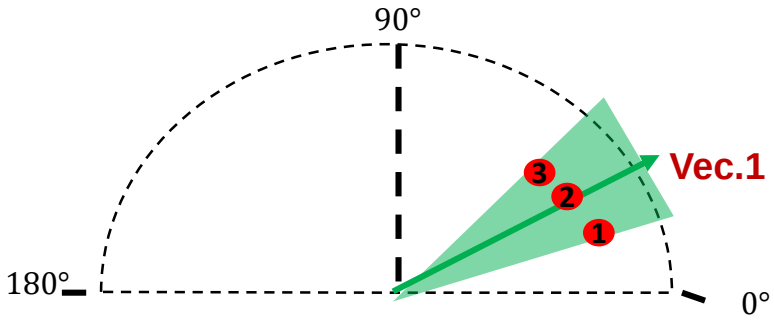
HPM Weapon Characteristics

Kinetic Weapon
(1 shot, 1 kill)



- **Kinetic requires minimally 1 shot per Target**
- **Precise tracking critical to complete fire control solution**
  - Maneuvering target lowers single shot probability of kill
- **Range: 250 - 750m**

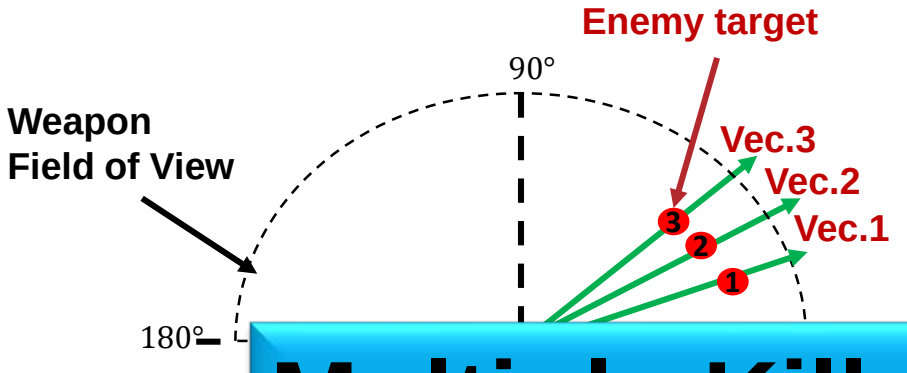
THOR
(1 shot, >1 kill)



- **HPM can provide One Shot on Many Targets**
  - System rotates 30deg/sec to support many engagement vectors with simultaneous time of arrival
- **Tracking is less critical based on speed of light effects**
- **Range: >750 m**

HPM Weapon Characteristics

Kinetic Weapon
(1 shot, 1 kill)



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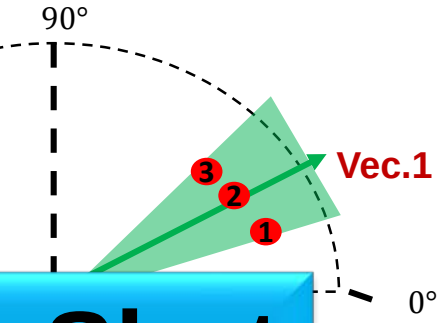


Multiple Kills in One Shot

- **…Shot on Many Targets**
  - System rotates 30deg/sec to support many engagement vectors with simultaneous time of arrival
- **Tracking is less critical based on speed of light effects**
- **Range: >750 m**

HPM Effects

- Expanded effects understanding in counter-UAS and counter-missile

Front Door Coupling Paths

- HPM field couples to antennas
- In-band HPM energy at receiver
- Vulnerable components: low noise amplifiers (LNAs), limiters
- Effect is generally ***damage***
- Can achieve EW-like effects with upset

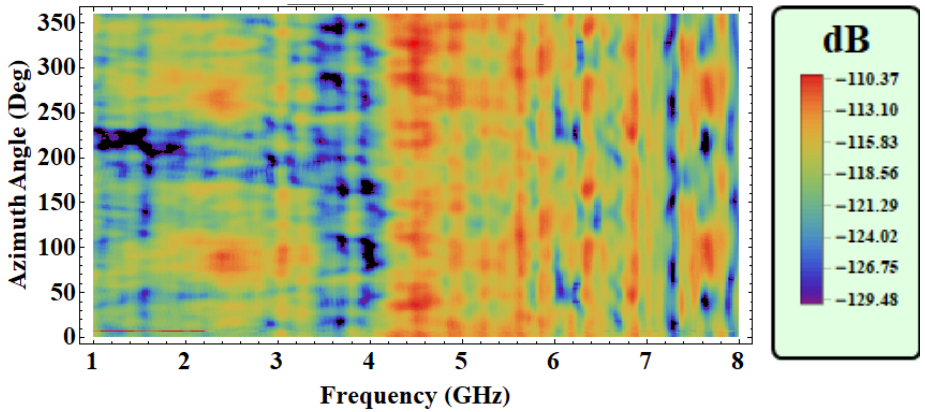
Back Door Coupling Paths

- Control / guidance systems involve digital electronics
- HPM field couples to control wires (e.g. UAS), internal cables (e.g. missile)
- Effect typically ***disruption*** of digital electronics

DJI Phantom 4

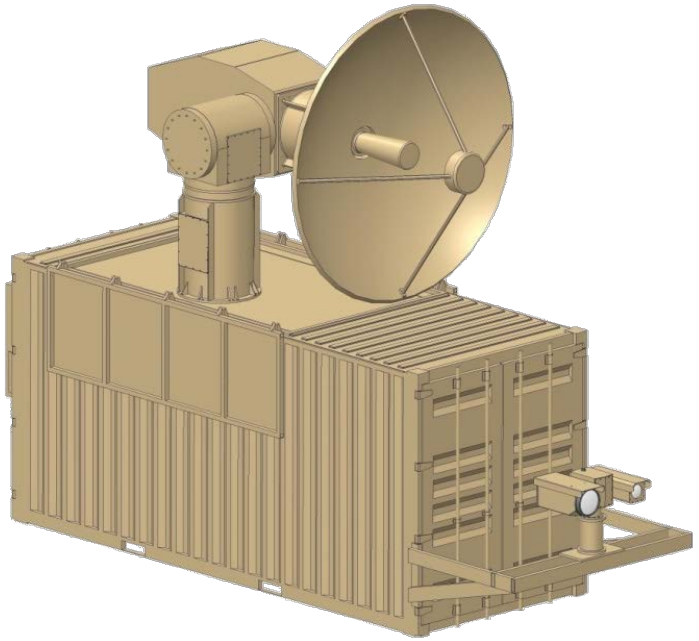
Electronic Speed Controllers

RF absorption by azimuth & frequency

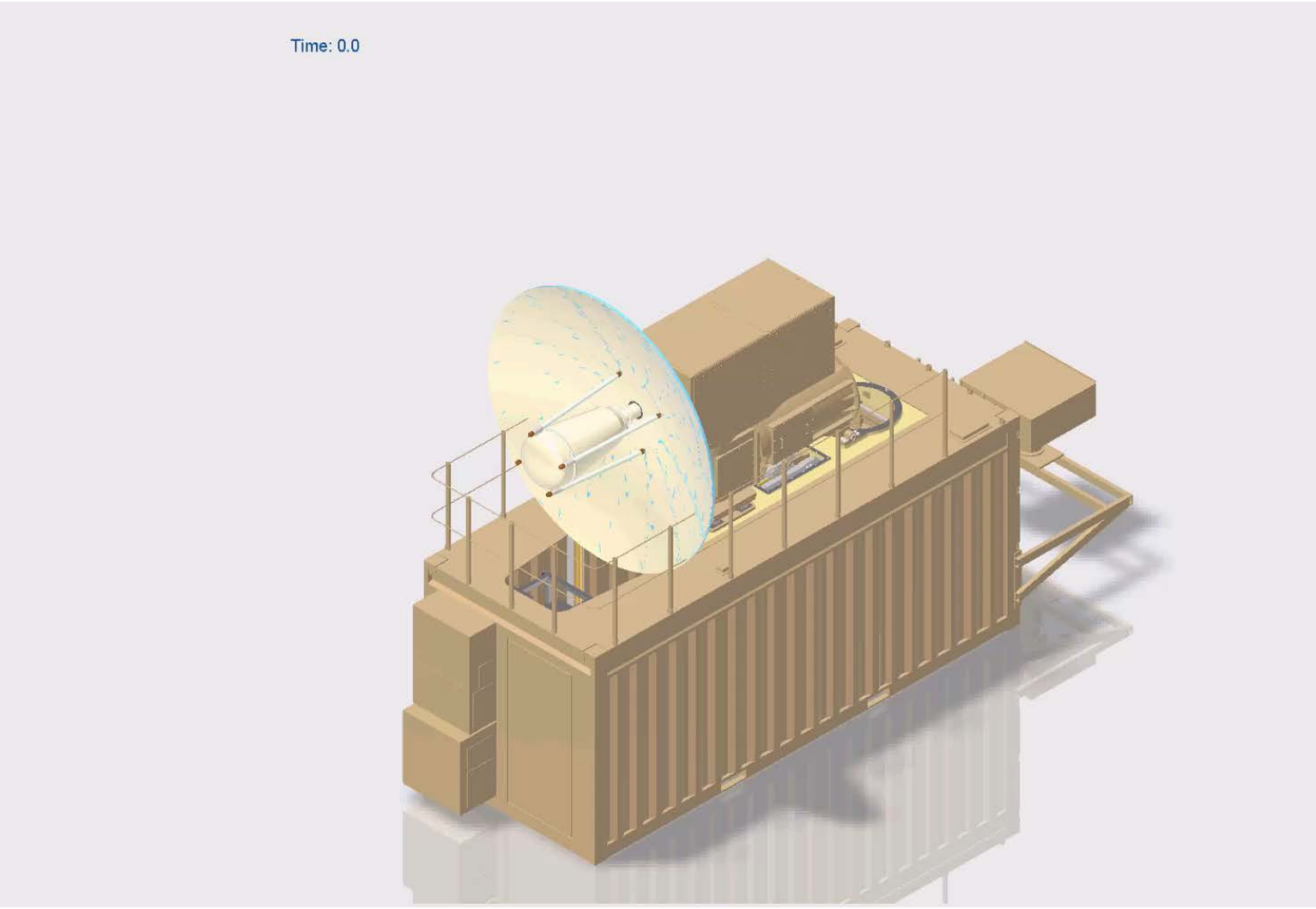


Tactical High-power-microwave Operational Responder (THOR)

- Directed Energy Weapon specified by HyDRA Study
- Demo a non-kinetic kill of autonomous class 1 UAS swarms
  - Rapidly develop Advanced Technology Demonstrator suitable for integration into Air Base defense control
    - Near term: 18mo. to Transition
  - Transportable
  - Engagement of UAS at ranges less than 2km
  - Integration with existing C2 and standalone operation
  - **Demonstration in real-world scenario Summer 2019**



THOR: Operational Focus



- Currently has a stand-alone operations control
- Integration with Maneuver Aviation Fires Integrated Application (MAFIA) and Forward Area Air Defense (FAAD) C2 planned
- Designed for One/Two Person Setup
- No tools required for antenna assembly
- Withstand winds up to 125mph
- Organic EO/IR for dedicated Find/Fix/Track/ID

S&T to Make HPEM Weapons Airman Ready

THEN…

PhD operated,
Bulky,
No environmental hardening,
Not Aerodynamic

NOW!

Warfighter operated,
Smaller,
Ruggedized,
Demonstrated aerodynamics