



PAST PRESENTATIONS

1. **Enhancing and Developing Directed Energy Testing:** Colonel Richard Haggerty, Project Manager ITTS, PEO STRI
2. **Implementing DES Into the Shorad Strategy to Counter Group 1 UAS:** Col (R) John Haithcock, Director, Fires Battle Lab, Fires Center of Excellence
3. **Providing Distributed Lethality with Directed Energy and Kinetic Platforms:** Colonel Michael "Moses" Thompson, Chief, Advanced Weapon Systems Division, ACC USAF
4. **Defense Laser Weapons for Air Mobility Platforms:** Dr. Donna C. Senft, Chief Scientist, Air Mobility Command, US Air Force
5. **Integrating Directed Energy Technology to Counter UASs and Forward Base Defense:** Dr. Michael Jirjis, Directed Energy Experimentation, Lead, Strategic Development, Planning & Experimentation, US Air Force
6. **Joint Laser Systems Effectiveness Joint Test:** Mr. Scott Boyd, Director JLaSE Joint Test, NSWC Dahlgren
7. **Energy Storage and Power Systems for DEW Applications:** Rich Schroeder, Director, Business Operations, EaglePicher Technologies
8. **High Energy Laser Technology for the Multi-Domain Battlefield:** Thomas Webber, Director, USASMD/ARSTRAT Technical Center
9. **AFSOC Airborne High Energy Laser Initiative:** Lieutenant Colonel Oluyomi "Yomi" Faminu, Division Chief of Technology, SOCOM
10. **Energy Magazines for Directed Energy Weapons and Back-up Power:** Don Klick, Director Business Development, Leonardo DRS Naval Power Systems



PM ITTS

Enhancing and Developing Directed Energy Testing



COL Richard Haggerty

Project Manager, Instrumentation, Targets, Threat Simulators and SOF Training Systems (PM ITTS)

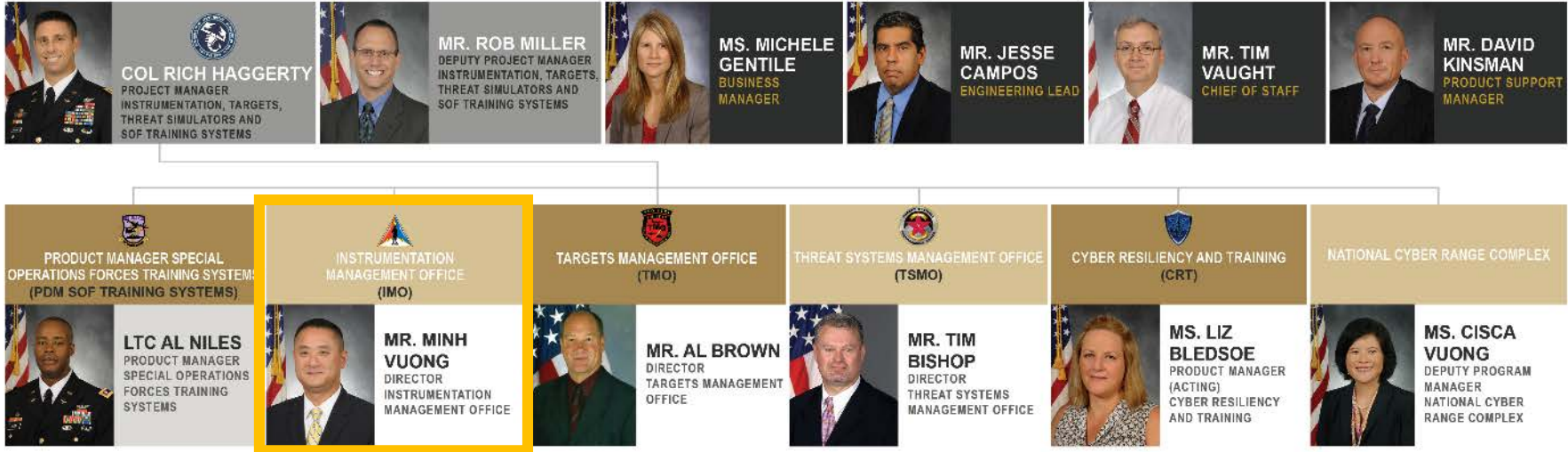


Opening Remarks and Purpose

Provide an overview of the PM ITTS organization, its doctrinal alignment to the joint Test and Evaluation (T&E) community, some challenges and gaps associated with T&E, and a brief update on current efforts for awareness



PM ITTS Team



CSL

Last updated: 10 MAY 2019

- ✓ 275 Military, Civilian, and Contractor Professionals in Multiple States
- ✓ \$550M Annual Budget
- ✓ 110 Programs and Activities
- ✓ Unclassified to Support of Special Access Program (SAP) Efforts
- ✓ Science & Technology to Sustainment Efforts
- ✓ Several Unique Acquisition Authorities



PM ITTS Relationship to T&E

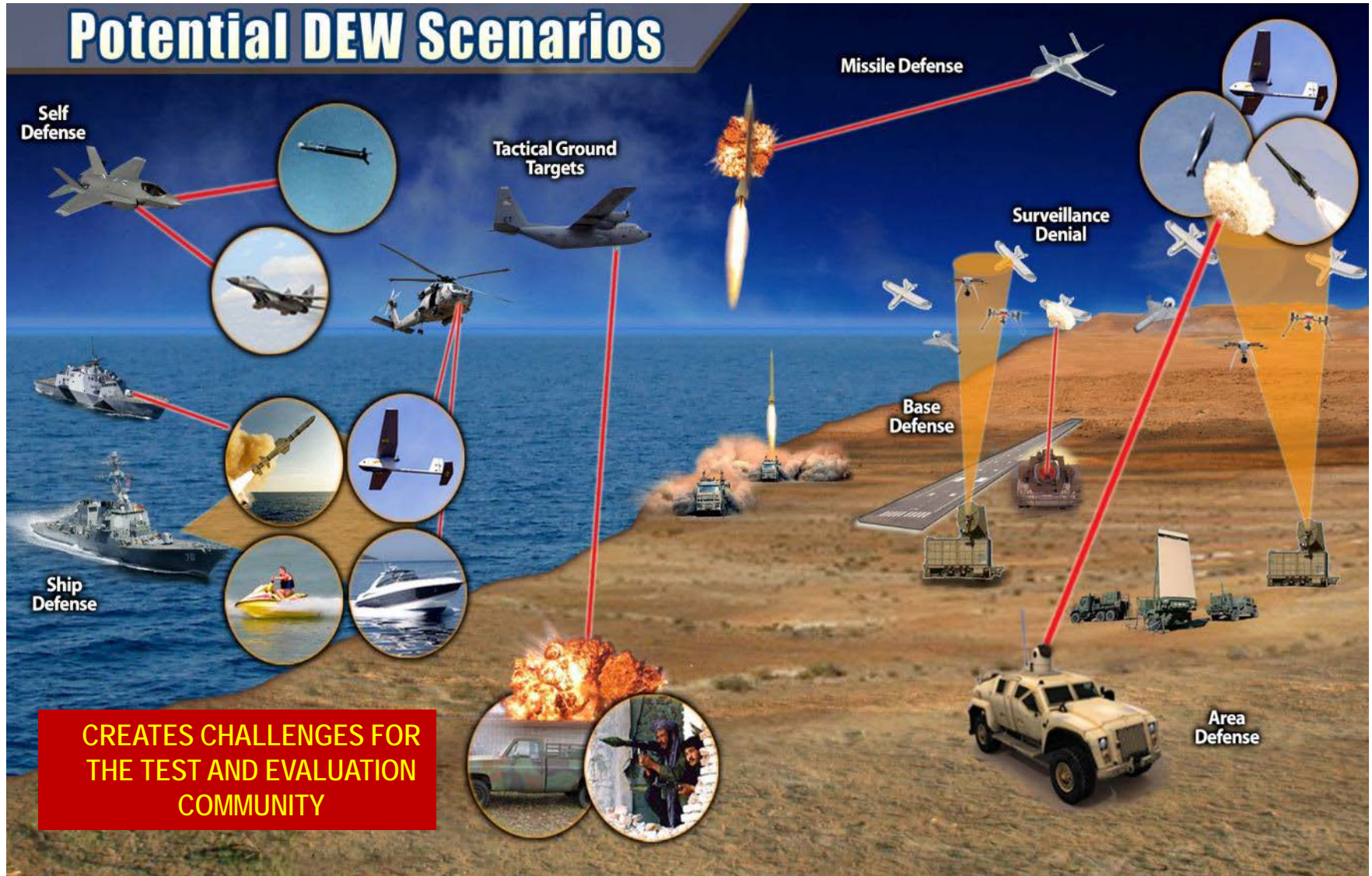
Office of the Secretary of Defense

U.S. Army





Potential Directed Energy Battlespace





Critical Gaps in the T&E Enterprise

- ✓ Accurate and relevant survivability models
- ✓ Relevant threat-representative systems
- ✓ Instrumentation to reliably measure energy on the System Under Test (SUT)
- ✓ Accurate and relevant atmospheric effects model to measure performance

Testing Speed of Light systems is very different than traditional kinetic systems, which creates challenges for the Test and Evaluation community



High Energy Laser T&E Challenges

- ✓ Infrastructure and instrumentation insufficient to effectively test mature Directed Energy systems
- ✓ Laser safety consideration
- ✓ Repeatable statistical data/ effects
- ✓ Doctrine and Policy
 - No MIL-STD
 - Accepted community test standardization processes



Supporting the TRMC Mission Portfolio

Test Resource Management Center (TRMC) Mission: Ensure the Test and Evaluation (T&E) community has the capabilities to support current and future weapon systems



SCIENCE AND TECHNOLOGY PORTFOLIO

HIGH ENERGY LASER

Maritime Atmospheric
Characterization System (MACS)

Irradiance Collection and Reporting
System (ICRS)

Big Area Target System (BATS)

ICRS Recoverable Rocket

Modeling and Simulation of Aircraft
Survivability (MSAS)

HIGH POWER MICROWAVE

Wide Band Test Array System (AWBS)

Vertical Sensor Net Array (VSNA)

Enhanced Sensor Net Array (ESNA)

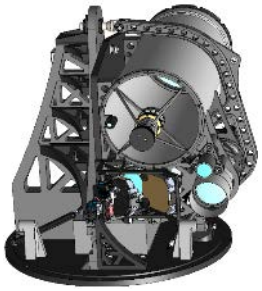
CENTRAL TEST AND EVALUATION INVESTMENT PROGRAM PORTFOLIO

MOBILE HIGH ENERGY LASER MEASUREMENT (FY19 NEW START)

TBD

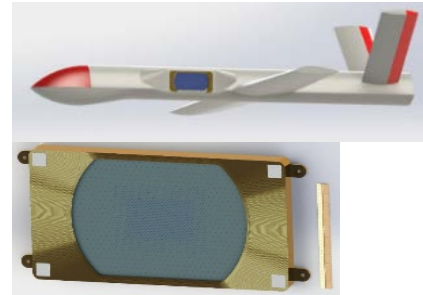


Portfolio Take Aways (1 of 2)



Maritime Atmospheric Characterization System (MACS)

- ✓ Lidar-based aerosols characterization
- ✓ Provides laser extinction measurement
- ✓ Challenging to calibrate Lidar
- ✓ Delivered to Navy: 1QFY18



Big Area Target System (BATS)

- ✓ Measures HEL irradiance on group 3 UAS
- ✓ Survivable up to 10kW/ cm² for 10 seconds
- ✓ Will deliver to Navy and SMDC: 4QFY18



Irradiance Collection and Reporting System (ICRS)

- ✓ Measures irradiance on 81mm mortar
- ✓ Successful demonstration at WSMR
- ✓ Delivered to WSMR: 3QFY18

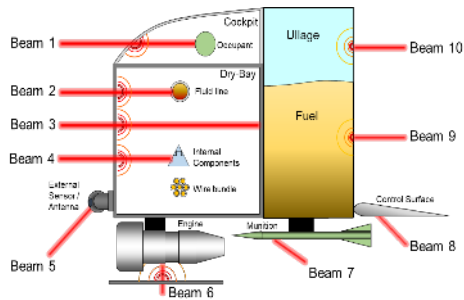


ICRS Recoverable Rocket

- ✓ Measures irradiance on rocket
- ✓ Low cost recoverable rocket
- ✓ Delivered to WSMR: 3QFY18



Portfolio Take Aways (2 of 2)



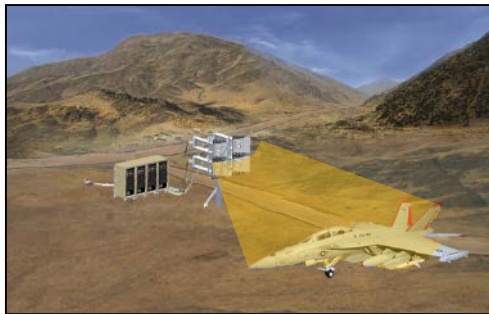
Modeling and Simulation of Aircraft Survivability (MSAS)

- ✓ Informs aircraft hardening requirements
- ✓ Very challenging to address all potential vulnerable areas
- ✓ Delivery to Air Force: 3QFY22



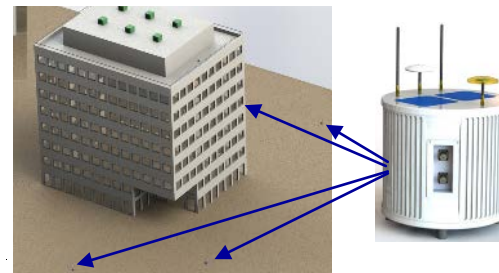
Vertical Sensor Network Array (VSNA)

- ✓ Enables vertical HPM beam mapping
- ✓ Challenging to cover a large diverging beam
- ✓ Delivery to Air Force: 1QFY19



Advanced Wide Band System (AWBS)

- ✓ Enables full system HPM susceptibility test from 30-300MHz
- ✓ SWAP is an issue for low frequency antenna design
- ✓ Delivery to Navy: 1QFY22

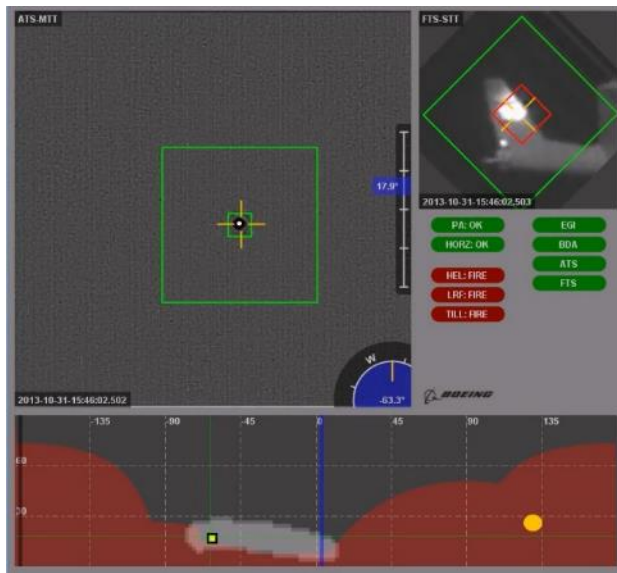


Enhanced Sensor Network Array (ESNA)

- ✓ Enables network of HPM sensors
- ✓ Records field strength
- ✓ Delivery to Navy: 1QFY19



Target Support to Directed Energy Activities





Closing Remarks

- ✓ The T&E community is not ready to test mature Directed Energy systems today
- ✓ PM ITTS is doctrinally and programmatically aligned with the joint Test and Evaluation community, and collaborating with key stakeholders to start bridging the gaps
- ✓ PM ITTS efforts have developed capabilities supporting the full-spectrum of Directed Energy T&E

Implementing Directed Energy Into SHORAD Strategy



***John Haithcock
Director, Fires Battle Lab***



Agenda



- **Implementing DE into SHORAD Strategy**
- **Maneuver Fires Integration Experiment (MFIIX)**



SHORAD Approach



"Short Range Air Defense (SHORAD) are those **dedicated Air Defense Artillery** and **non-dedicated air defense** capabilities which enable movement and maneuver by destroying, neutralizing, or deterring low altitude air threats to defend **critical fixed and semi-fixed assets** and **maneuvering forces**."

Dedicated ADA

Primary mission

Beyond LOS and LOS engagements
Highly structured Mission Command
Operating on a Fire Control Network

LOE 1: M-SHORAD Maneuvering Forces

- Current: **No capability**; Divisional ADA units divested in the early 2000s
- Protects "Maneuvering Forces" against 3rd dimension air threats aircraft
- **Mobility & survivability compatible** with the supported Force
- Trades "firepower" for "mobility" to keep up with the supported maneuver force which are less vulnerable to massed fires and complex attacks due to their mobility

LOE 2: IFPC Inc 2 Fixed & Semi-Fixed Assets

- Current: **Avenger & Land-Based Phalanx Weapon System (LPWS)**
- **IFPC replaces Avenger & LPWS**
- Protects critical "Fixed and Semi-Fixed" assets
- Fixed and semi-fixed assets are at greater risk due to massed fires and their inability to move
- IFPC's strength lies in its **engagement firepower**

Mobility

Firepower

IFPC Inc 2-I and M-SHORAD are complementary systems that provide layered and tiered air defense of critical assets

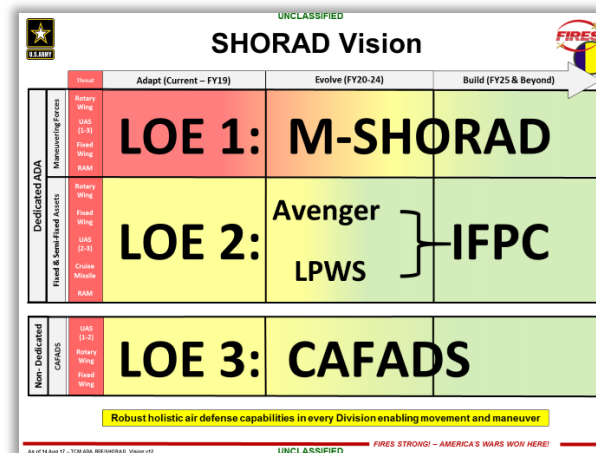
Non-Dedicated AD

Secondary mission

LOS engagements
Controlled by ROE
Organic Network

LOE 3: CAFADS "Self Defense is never denied"

Combined Arms for Air Defense (CAFADS) are **active and passive defense measures** taken by the force to protect itself from threat air surveillance and attack





SHORAD Vision



		Threat	Immediate	Interim	Future
Dedicated ADA	Maneuvering Forces	Rotary Wing	Maneuver-SHORAD "Demo"	Initial Maneuver-SHORAD	Objective Maneuver-SHORAD
		UAS (1-3)			
		Fixed Wing			
		RAM			
	Fixed & Semi-Fixed Assets		Maneuver Stinger	Stinger w/ Prox Fuse	Improved MANPAD Capability
					Next Gen MANPADS
		Rotary Wing	Avenger/Stinger	Indirect Fire Protection Capability (IFPC) Block 1 – UAS, Cruise Missile, Fixed & Rotary Wing	
		Fixed Wing			
		UAS (2-3)	Land-Based Phalanx Weapon System (LPWS)		IFPC Block 2 – adds RAM <ul style="list-style-type: none">• Adv Missile or• Direct Energy
		Cruise Missile			
		RAM	Sentinel A3		Sentinel A4
Non-Dedicated	Combined Arms for Air Defense (CAFADS)	UAS (1-2)	Individual/crew weapons	Guided Rounds	
				Directed Energy	
		Rotary Wing	C-UAS rapid capability solutions	Multi-Mission Radars	
		Fixed Wing			
			Apache		Multi-Functional Electronic Warfare

Legend
Programs/ Initiatives

Robust holistic air defense capabilities in every Division enabling movement and maneuver



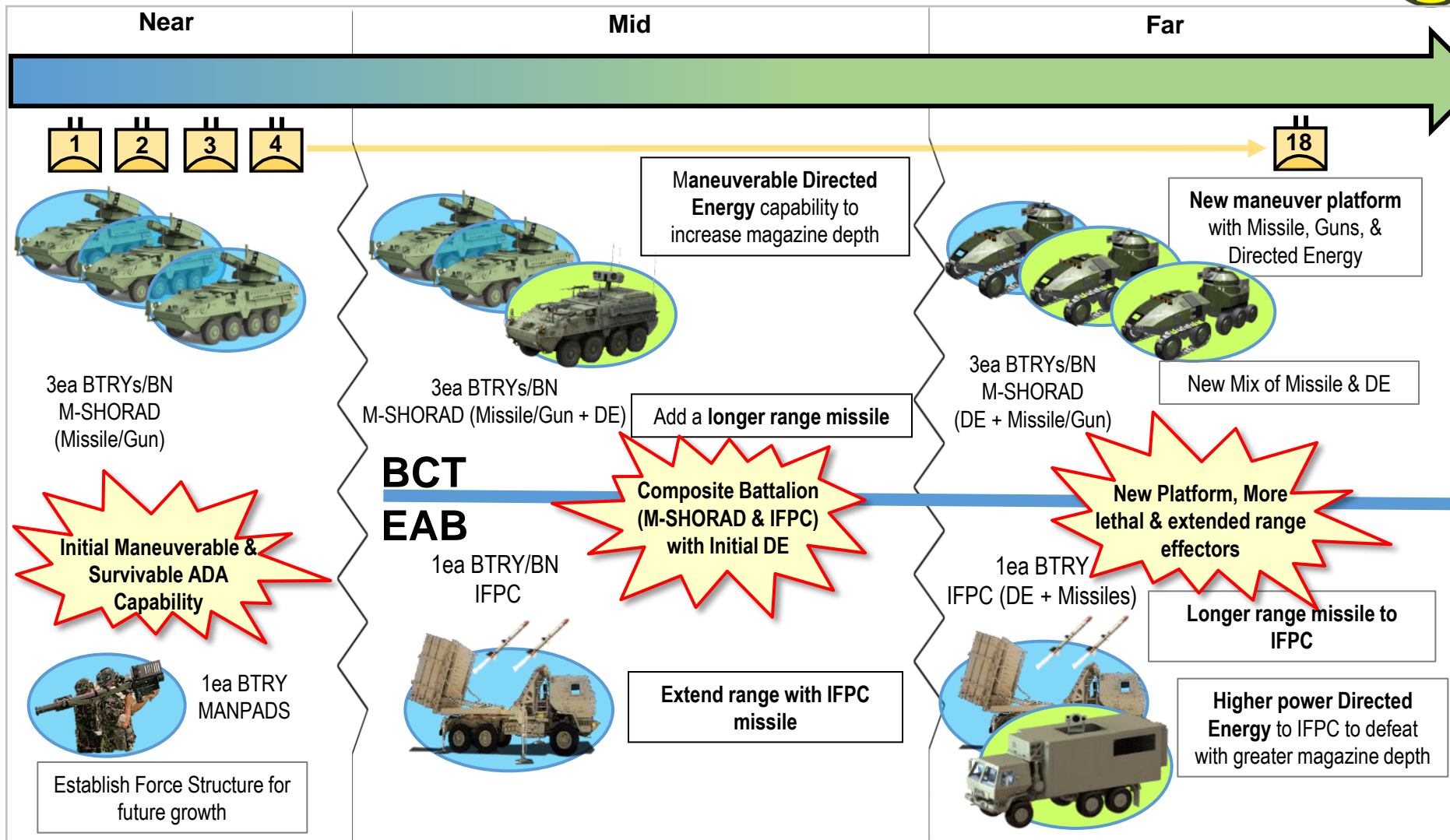
Formations and Capabilities

Growth of the Maneuver-Short Range Air Defense (M-SHORAD) Battalion

Near

Mid

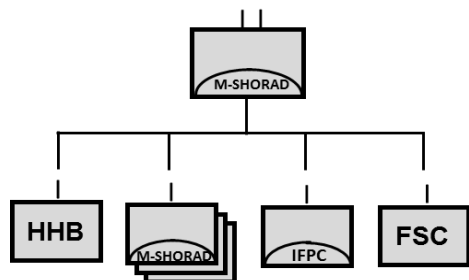
Far



Composite Formations and Mix Capabilities Mitigate Risk Over Time

Maneuver-SHORAD Operations and Organization

Composite Organization



Shooters

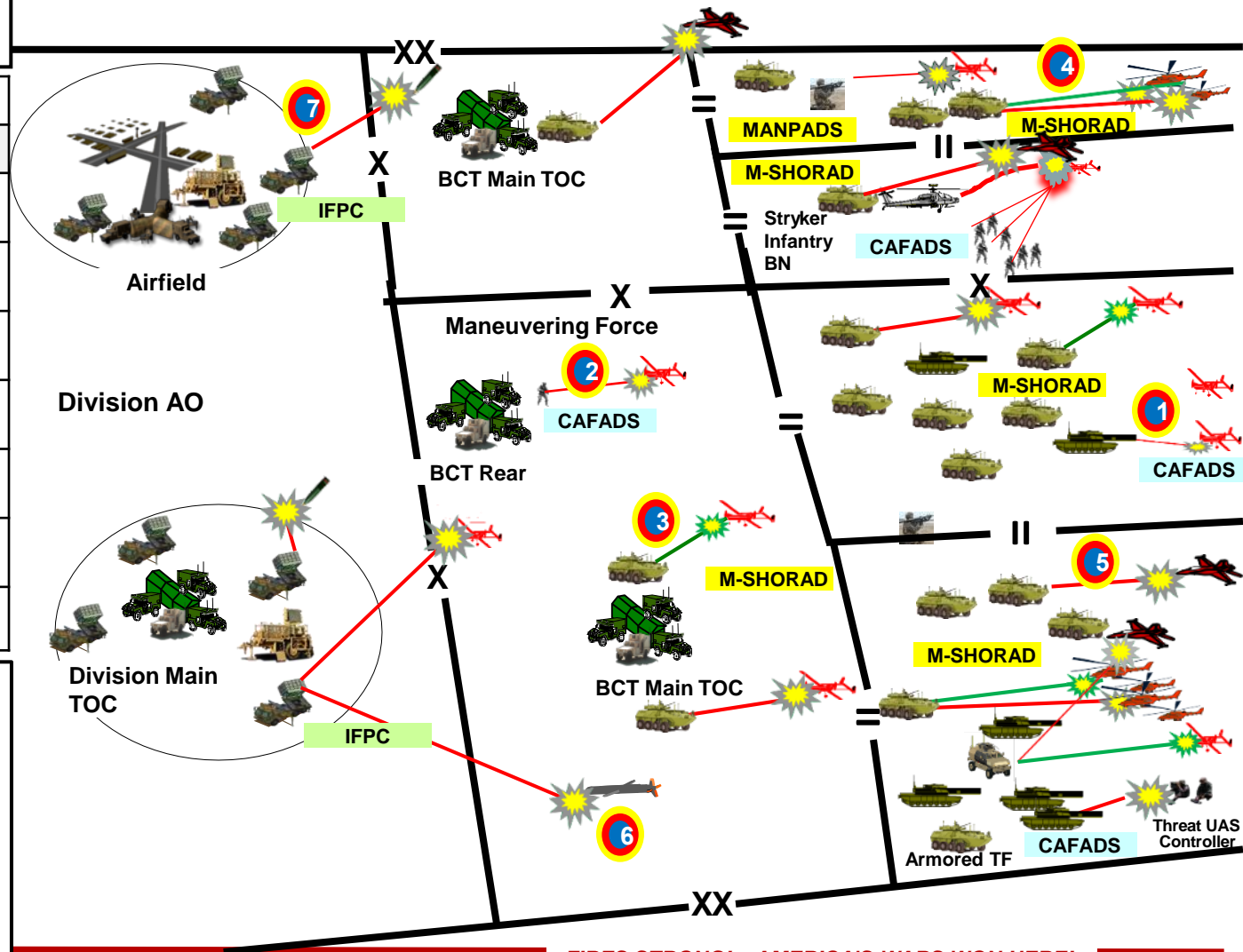
Threat	Primary	Secondary
UAS 1 (up to 3km)	CAFADS	M-SHORAD
UAS 2 (up to 6km)	CAFADS	M-SHORAD
UAS 3 (up to 6km)	M-SHORAD	IFPC
Rotary Wing (up to 8km)	M-SHORAD	IFPC
Fixed Wing (up to 8km)	M-SHORAD	IFPC
Cruise Missile (Up to 16km)	IFPC	N/A
RAM	IFPC	M-SHORAD

Complementary Layered & Tiered Capabilities

- Maneuver SHORAD (M-SHORAD)**
 - Defend a maneuver force from aerial attack
- Indirect Fire Protection Capability (IFPC)**
 - Defend fixed/semi assets from massed fires
- Combined Arms for Air Defense (CAFADS)**
 - Secondary self defense by all Warfighters

Legend

- Kinetic Engagements
- Non-Kinetic Engagements





Maneuver and Fires Integration Experiment (MFIx) Premier Venue for Prototype Experimentation



Purpose: Develop, evaluate and expand integrated concepts and material capabilities in order to inform how Fires enhances tactical operations at Brigade and below, retain current advantages over adversaries and accelerate investments on contested future capabilities in support of the Army's Campaign of Learning (CoL).

Method: The Maneuver Brigade's Fires Cell (FA, ADAM/BAE, Space, and CEMA) employs cross-domain fires in direct support to the Brigade Combat Team.



FY 19 Objectives

- Mission Command for Fires Synchronization and Integration in Multi-Domain Battle.
- Future Platforms that enable/facilitate cross-domain fires.
- Sensor to Shooter Linkages that will enable/facilitate cross domain fires, target acquisition, and transfer of data from sensor platform through positive identification.
- Provide an ALPA venue for CoE focused assessments and government demonstrations.

MFIx 19 Key Tasks

Establish
Sensor to
shooter
linkages

Detect, identify,
and defeat a
wide range of
aerial threats

Conduct
counter-
battery
fires

Integrate sensors
and shooters
both organic and
attached

Conduct
tactical
targeting

Provide close
support and
shaping fires

Integrate Army
and joint
capabilities at
the tactical level

Technologies

System Highlights:

- 35 systems to include integrated Programs of Record participating at Brigade and below
- 10 New Systems (Government & Industry)
- 20 Returning Technologies
- 40 Total Tech Submissions

Experiment Design

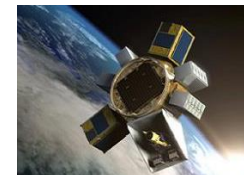
- **FY 19 Objectives:** Mission Command for Fires
Future Fires Platforms
Cross-domain sensor to shooter
Non-Line of Sight Engagements
- **White Cell:** Maneuver and Fires Battalions
- **Tactical Units:** Brigade (-), ADA Battery, Maneuver Company
- **Cross-Domain Tactical Vignettes**
- **Above the Horizon Laser Engagements**
- **Support SCoE and MSCoE focused assessments**



AUGS with 30mm



Silent Saber



Kestrel Eye



FLIR Light Tactical Vehicle (LVSS)



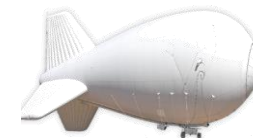
MEHEL (10kw)



HEL MTT (60kW)



HELWS (10kw)



Aerostat



Brutus (Truck Mounted 155mm)

Headquarters Air Combat Command

ACC Directed Energy Activities



Colonel Michael “Moses” Thompson
Chief, Advanced Weapons Systems
ACC/A5/8ZW

This Briefing is:
UNCLASSIFIED



USAF Strategic Master Plan

Priorities

- Develop capabilities to ensure freedom of action for the joint force
- Leverage and integrate new approaches, technologies and capabilities
- Deliver more effects at range
- Increase resiliency when presence within the battlespace is required
- Retain the ability to operate across the full spectrum of operations



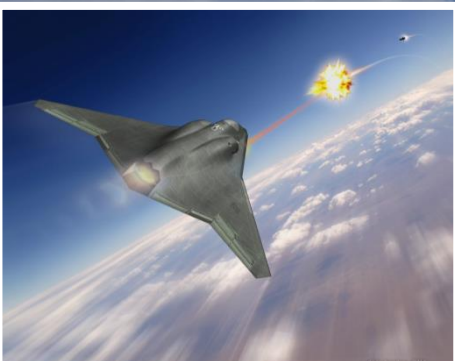
Directed Energy (DE) is a “game-changing” technology

Joint collaboration in technology development and maturation is necessary to move Directed Energy out of the Labs into Operations



Why is DE important to ACC?

Directed Energy Weapons (DEW) have the potential to enable our Airmen to effectively, affordably, and rapidly defeat massed attacks from an adversary and to precisely strike critical targets with little/no collateral impacts or detectable disturbance and provide protection to assets that must operate in harm's way.



- Lethality: Defeat enemy's ability to F2T2EA & use offensively against adversary threats
- Persistence: Rechargeable weapons allow greater station time & magazine depth
- Asymmetric weapons with low/no collateral damage
- Defensive Capability: Keep threats outside of damage zone

Though there are no formal ACC requirements for DEW, we continue to support efforts to develop/mature technologies that address capability gaps and solve warfighting problems



ACC Support to DEW Flight Plan

ACC supports efforts to operationalize DEW across the enterprise in order to complement kinetic weapons and deliver key battlefield, and other operational environments, effects against adversary forces and technologies



United States Air Force
Directed Energy Weapons
Flight Plan
April 2017

Signed by SECAF and CSAF
22 May 2017

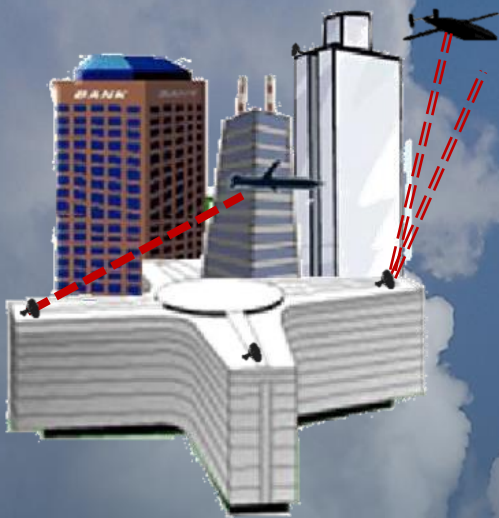
3 Operational Use Cases

- Forward Airbase Defense
- Precision Strike
- Aircraft Self Protect



Forward Airbase Defense

Forward bases and operating locations for the USAF can no longer be considered sanctuaries. From an AF doctrinal perspective, protection of these locations from attack through the air is included under Defensive Counter Air.



Key Threats

- UASs
- RAMs (Rockets, Artillery, and Mortars)
- Cruise Missiles
- Ballistic Missiles

Key Enabling Technologies

- High Energy Lasers (HELs)
- High Powered Microwaves (HPMs)



The 2016 Hybrid Defense of Restricted Airspace (HyDRA) study enabled scenario and CONOPs development to inform military utility assessments of both systems for area and point defense.



Precision Strike

The ability to hold targets at risk while limiting collateral damage and/or impacts to the civilian populace, as well as mitigating reconstruction costs once hostilities cease, is a capability that affords our leaders greater flexibility

Airborne HPM



Gunship HEL



HPM

- Mission Evaluation of Next Airborne Counter Electronics (MENACE)
 - Military Utility study to assess kinetic vs. non-kinetic tradespace
- High Power Joint Electromagnetic Non-Kinetic Strike (HIJENKS)
 - Joint AF-Navy prgm to develop a multi-mission, multi-tgt weapon; aiming f/ flight test in FY22

HEL

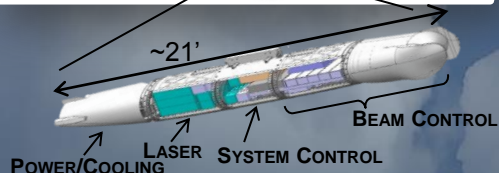
- Assessing limitations against target sets
- CONOPs for kinetic/HEL employment balance



Aircraft Self Protect

Environments within which we operate are becoming increasingly contested and our ability to protect our platforms and Airmen operating there is vitally important.

ACC supports efforts to advance DE solutions with the potential to provide rechargeable, deep-magazine protection capabilities against advanced threats.



Self Protect High Energy Laser Demonstrator (SHIELD) ATD

- Demos a rechargeable HEL in a relevant fighter environment to defeat relevant missile threats
- Reduce/retire risk, meet/resolve tech challenges of power-scaling, beam qual, thermal mgmt, and packaging
- Feeds parallel efforts to improve LWS capes f/ future fighter/bomber & HVAA protect
- Provides off-ramp capabilities as LWS matures

Laser Subsystem Development (LSD)

- AFRL/DARPA funded effort to dev 150kW laser
- Compact subsystem form fit to SHIELD pod
- Advances fiber laser tech to support ruggedized laser
- Enables off-ramps for ftr, tanker, HVAA, gunship prototypes
- Compliments AMC's Laser Weapon System (LWS) effort



A history of successful DE weapons systems demonstrations



1984: Airborne Laser Lab



**1990 – Present:
laser system research**



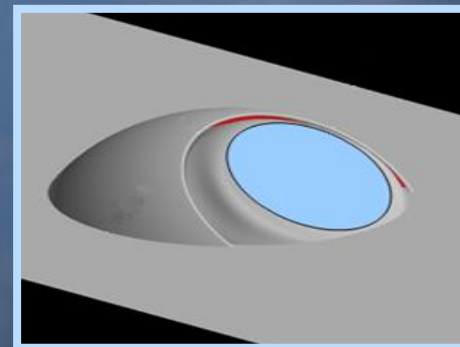
Fiber lasers



Active Denial System



MAX POWER IED Defeat System



**Advanced Beam
Control Turret**



DE Challenges (Opportunities)

- Technology challenges
 - SWaP-C
 - Integrated power & thermal management
 - Beam control advances to enable precise aiming/tracking/pointing amidst aero-mechanical jitter induced by vibrations during flight
 - High-speed aerodynamic flow mitigation to avoid aero-optical disturbances
- DEWs will not replace kinetic systems
 - LWS are not all-Wx; predictability of HPM effects TBD
 - Should be used to compliment Kinetic systems
 - Joint Munitions Effectiveness Manual (JMEM)
- Training/Testing
- DoD Roadmap
- Counter-DEW
 - Adversary investments to counter



Final Thoughts

“To ensure our nation continues to have the ability to strike anytime and anywhere, we must continue to blend stealth technologies and new technologies like...directed-energy weapons that can operate across domains.” - Gen Welsh

“Our sensor and C2 packages are getting better. We just need to enhance the technology which provides us with the low-cost, high-magazine and high-accuracy systems to go along with the sensor grid...Directed Energy Weapons are clearly part of the transition.” - Gen Carlisle

“The battlefield is changing, the character of war is changing. We need to be able to think about how we will use these systems on new battlefield and new paradigms. And we need help with industry to be able to move forward and take the ideas that make all these things possible and find ways to do them faster and sooner.” - Gen Holmes

- DE has significant senior leader attention
- Now is the time to move out on DEW initiatives
- Warfighter input throughout the process is critical

Headquarters Air Mobility Command



Defensive Laser Systems for Air Mobility Platforms

**3rd Annual Directed Energy Systems Summit
June 25, 2018**

**Dr. Donna C. Senft
AMC Chief Scientist**

Distribution A: Approved for public release

Unrivaled Global Reach for America ... ALWAYS!



Defensive High Energy Laser Systems



- Air Mobility Command supports the development of airborne high energy laser weapon systems to defend mobility aircraft from incoming missile threats



**ABL –
circa 2002**

Unrivalled Global Reach for America ... ALWAYS!

Headquarters Air Mobility Command





Airlift



Air Refueling



Air Mobility Support



Aeromedical Evacuation





Development and Transition Path



- AMC is relying on government and industry partners to mature laser systems for mobility aircraft
 - **Science and Technology Development:** Air Force Research Laboratory (AFRL)
 - ♦ Self-protect High Energy Laser Demonstrator (SHiELD) program
 - **Experimentation:** Strategic Development Planning and Experimentation (SPDE)
 - ♦ Dr. Michael Jirjis presentation
 - **Prototyping:** AF Life Cycle Management Center (AFLCMC)
 - ♦ High Energy Laser (HEL) Flexible Prototype
 - Industry laser development (IRAD)
 - Other DoD Programs



Unrivaled Global Reach for America ... ALWAYS!



AFRL SHiELD



■ Technical Challenge

- Design, develop, and demonstrate laser weapon systems that are:
 - ♦ Sufficiently compact and robust to fit on aircraft
 - ♦ Operate within relevant stressing flight environments
 - ♦ Deliver sufficient power to defeat incoming threats

■ Program Approach

- Phase I: Low power in-flight demonstration
 - ♦ Demonstrate the ability of the beam control subsystem to acquire, track, point, and focus a low energy laser onto a dynamic, non-cooperative target
 - ♦ Demonstrate the aero-effect mitigation capability (compensate for the aerodynamic flow induced vibration and beam spread).
- Phase II: High energy laser subsystem
- Full demonstration of the self-protect capability by lethal engagement of incoming threats



AFRL SHiELD, continued



■ Timeline

- Currently in the design phase for the laser, beam control, system control, power, and thermal subsystems, as well as the pod structure
- Test strategy is being finalized
- Ground and flight tests for Phase I testing in 2019

■ SHiELD Contractor Awards

- **Turret Research in Aero-Effects (STRAFE) – Northrop Grumman**
 - ♦ Develop the beam control subsystem, including the turret, which will mitigate aero-effects
- **Laser Pod Research and Development (LPRD) – Boeing Company**
 - ♦ Develop the aero-dynamic structure which houses the laser system and the ancillary subsystems including power and thermal management and control subsystems
- **Laser Advancement of Next-Generation Compact Environments (LANCE) – Lockheed Martin-Aculight**
 - ♦ Develop the high energy laser source that will operate in the flight environment in phase II



Directed Energy Systems

- Beyond S&T -



- Progress is being made on the technical aspects of directed energy systems
- As we move toward prototypes, other questions are starting to arise:
- Acquisition/sustainment:
 - Ease of repair/ maintainability
 - Affordable upgrade path as laser technology continues to mature
- Operational issues
 - Reliability
 - Pilot interactions
- Early prototyping will serve to identify and prompt answers to these questions



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Air Force High Energy Laser Rapid Prototyping - AFLCMC



- **Air Force Materiel Command, Life Cycle Management Center released RFI on 6 June**
 - High Energy Laser (HEL) Flexible Prototype
 - Program manager: Doug Rogers
 - Interested in rapid demonstration and verification of a laser weapon system (LWS) in a realistic operating environment for potential future integration with an airborne vehicle



Unrivaled Global Reach for America ... ALWAYS!



Conclusion



- **AMC is on the path towards employing directed energy defensive weapons to protect against incoming threats**
- **Laser systems have been integrated into several ground and sea military platforms, such as the Army's HEL-MD demonstrator and the Navy's LAWS laser demonstration system, as well as large airborne platforms, such as the Airborne Laser**
- **AMC is working with AFRL, SDPE, and AFLCMC to develop and prototype high energy lasers on mobility aircraft**
- **SHIELD and HEL Flexible Prototype will take these advances one step further in reducing size and weight and ruggedizing the system**



United States Air Force's Directed Energy Weapons Experimentation

2018

**Dr. Michael Jirjis
Chief, Directed Energy Experimentation
Air Force Strategic Development
Planning & Experimentation**



Strategic Development Planning & Experimentation (SDPE)



Air Force Warfighting Integration Capability

Air Force (USAF) Headquarters: Total Force, multi-domain operating concepts to implement the National Defense Strategy & enhance the joint and coalition fight

- **Identifies prioritized ways & means to guide future force**
- **Focus: Enterprise Mission Sets, Cross-Portfolio Capability, & Resource Alignment**



SDPE Roles & Responsibilities

Senior Air Force-Level Support for Capability Development and Execution

- **Perform AFWIC and 4-star identified priorities for experimentation, prototyping, analysis, and support capability development**
- **Focus: Provide rigor and capability to AF Capability & Transitional Experimentation Efforts**

SDPE quickly addressing high priority AF Enterprise Needs



Ongoing SDPE Activities

Strategic Support

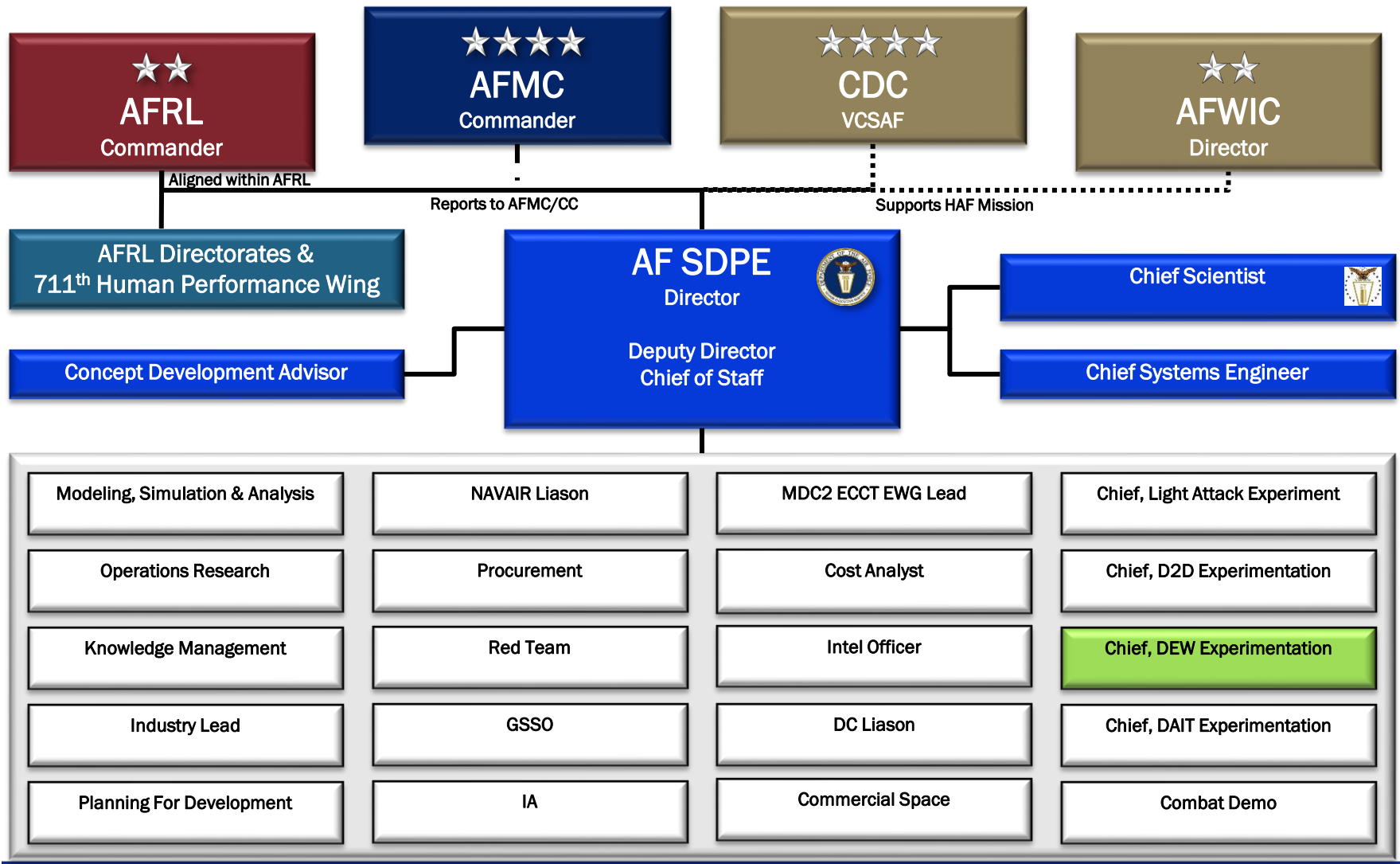
- **Delivering High Priority Capability Options for Long Term Air, Space, Cyber Dominance**
 - **Multi-Domain Command and Control**
 - **Air Superiority 2030**
 - **Electronic Warfare**
- **AF Capability Development**
- **AF Industry Engagements**

Campaign Examples

- **Light Attack Aircraft**
- **Data to Decisions (D2D)**
- **Defeat of Agile Intelligent Targets (DAIT)**
- **Directed Energy (DE) Experimentation**
- **AF Enterprise Model, Simulation, & Analysis**
- **Commercial Space Internet**
- **Pilot Training Next**
- **Personnel Recovery**
- **Adaptive Basing**



Organizational Structure & Reporting



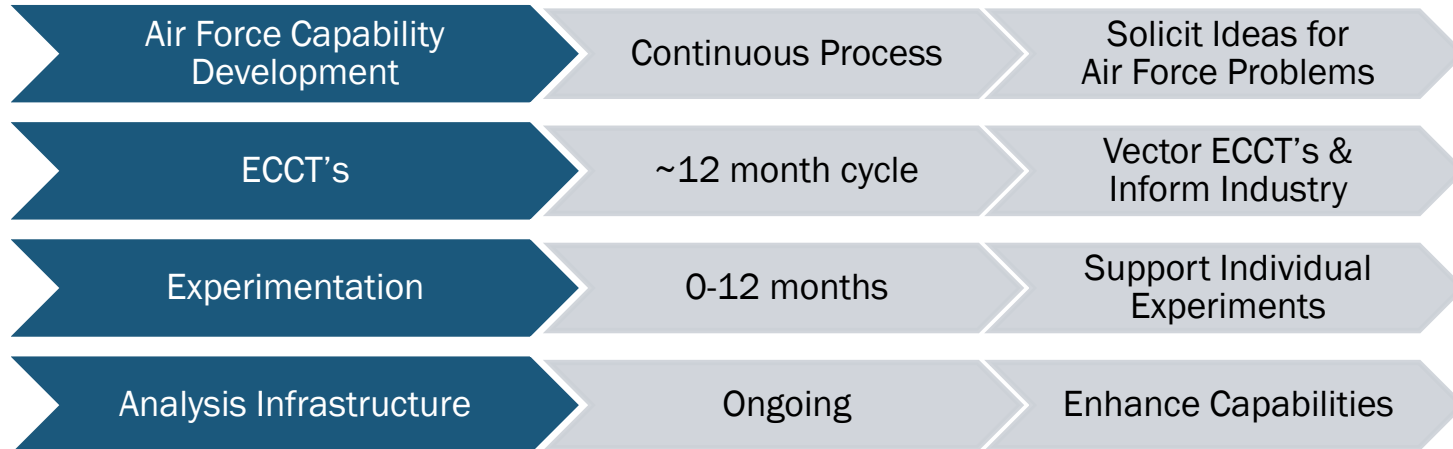







How We Engage With Industry

Industry Use Cases



Focusing on Engagement Left of Requirements

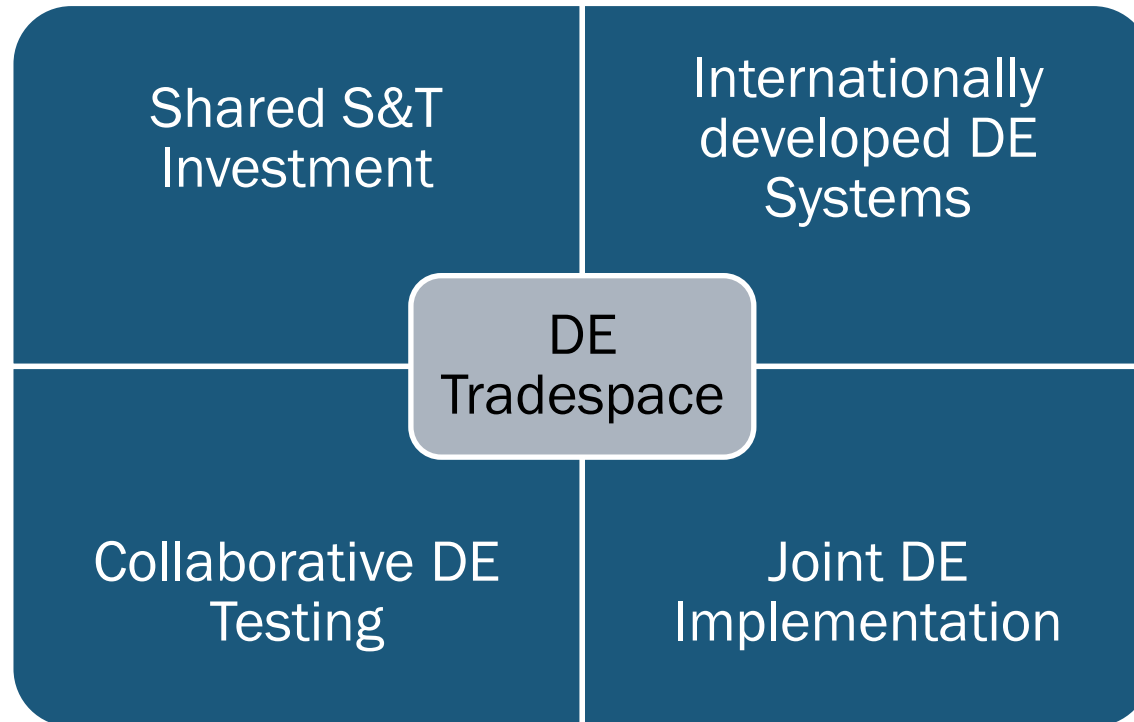


FY18 Q2			FY18 Q3			FY18 Q4			FY19 Q1		
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
											
											
	ECCT Review					Major AF Capability Development Events (Multiple Commands)					

Engagement Models Cannot Be “One Size Fits All”



How We Partner... With Other Countries



Engineer & Scientist Exchange Programs
Equipment Loans
Memorandums of Understanding

Data/Information Exchange Annexes
Cooperative Production Programs
Cooperative Development Agreements



Purpose of AF DEW Flight Plan



**AF Enterprise effort to support use of Directed Energy Weapons (DEWs)
Deliver key effects to the battlefield; nearly 30 directive actions**

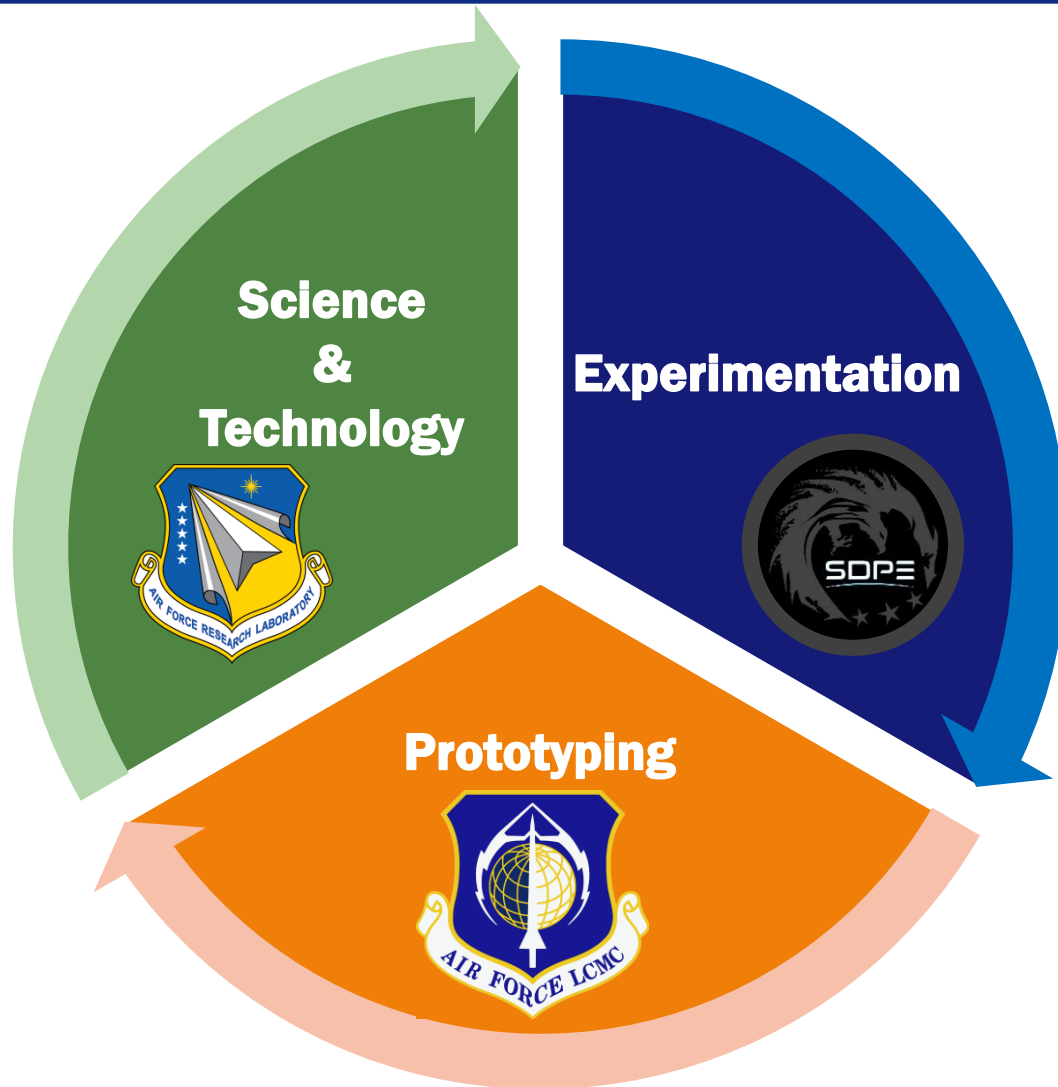
Identifies, Documents, Executes:

- Capability Gaps (where DEW are potential solutions)
- Required Investments
- Limitations/Constraints
- Test Infrastructure needs
- Transition timelines/milestones
- Life Cycle Acquisition Considerations
- **Experimentation**
- Transition Level Prototyping
- Science & Technology needs
- Doctrine, Organization, Training, Materiel
- Leadership and Education
- Personnel, Facilities, and Policy





Air Force Priority





Objective

Accelerate transition of DE weapons by evaluating aspects of the DOTMLPF-P spectrum via an experimental campaign

- **Perform unified planning, seamless execution, and combined analysis**
- **Informing investment strategies by working with operators and technologists to explore doctrine, policy, Concepts of Operation, Concepts of Employment, Tactics Techniques and Procedures, etc.**

Enable Developmental Planning



DEW Experimentation Campaign



- **Explore how DE weapons will be employed alongside existing:**
 - **Kinetic Weapons**
 - **Sensors**
 - **Command and Control**
 - **Battle management systems**
- **Put Warfighters at the Controls**
- **Use proven DE Prototypes**



Mission: Accelerate transition of DE Weapon Capability
and Inform Strategic Investment Decisions



AF DEW Experimentation Campaign



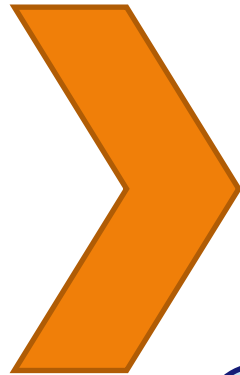
Senior AF Leadership Summits

June 2017
February 2018



United States Air Force
Directed Energy Weapons
Flight Plan
April 2017

Signed by SECAF and CSAF
22 May 2017



Four Parallel Experiments

2018-2021

1. Counter Unmanned Aerial Vehicle
2. Counter Cruise Missile
3. Precision Electronic Strike
4. Large Aircraft Defense

Experimental Approach



- Red Teaming
- Acquisition/Fielding Cost Analysis
- Develop/Validate Concepts of Operation

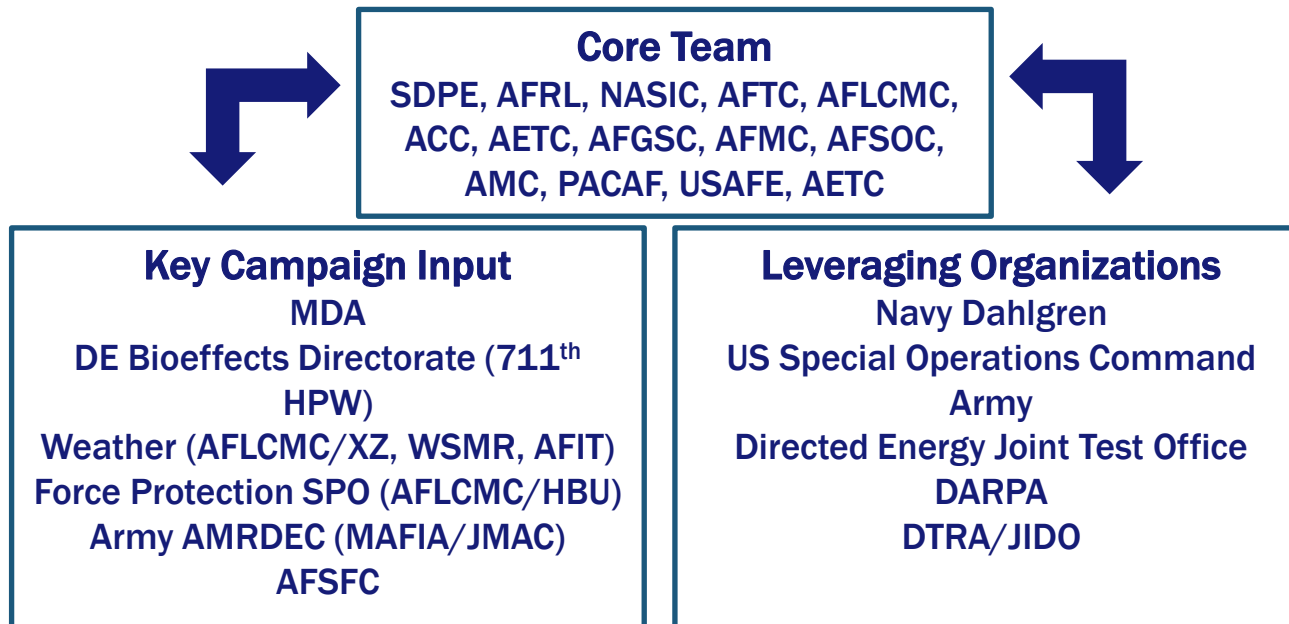


DEW Experimentation Campaign Customers/Stakeholders/Partners



Methods of Experimentation:

Wargame, MS&A, Red Team, Prototyping, Live Fire Experimentation Event



Leverage existing DE systems & development programs

(SHIELD, DENALI, HyDRA 2, etc.)

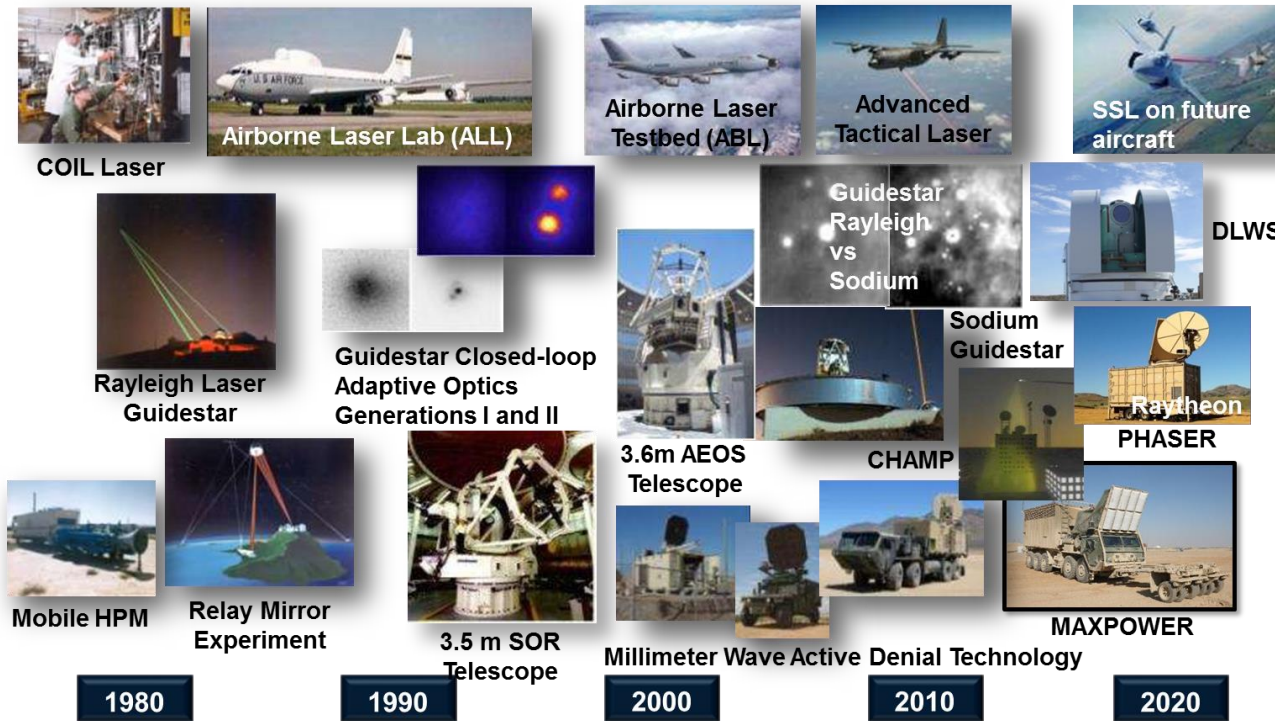
Partner with industry to explore available technological trade space

Engage DIUx to challenge non-traditional industry with relevant problems

(C-UAS around football stadiums, commercial airline protection, etc.)



Getting off the Stage



**United States Air Force
will lead the way for
Directed Energy use
for years to come!**

Transition DE Capabilities to lead and support the Joint Force in defending freedom, owning the high ground, and projecting power with our Allies.



**SLIDES ONLY
NO SCRIPT PROVIDED**

**CLEARED
For Open Publication**

May 07, 2018

**Department of Defense
OFFICE OF PREPUBLICATION AND SECURITY REVIEW**



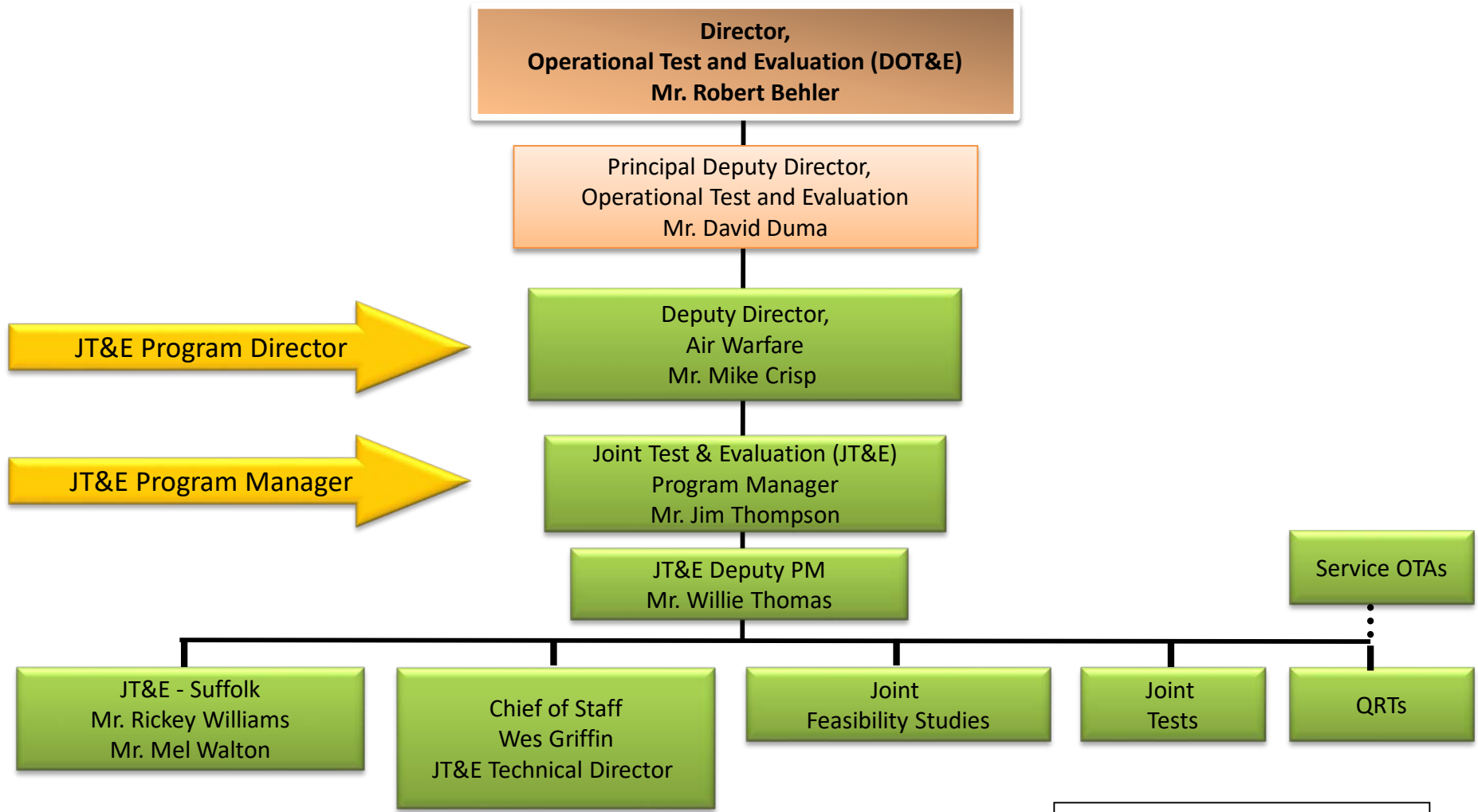
Joint Laser Systems Effectiveness (JLaSE) Joint Test Overview for the IDGA 3rd Annual Directed Energy and Next Generation Munitions

26 June 2018

**Mr. Scott Boyd
Joint Test Director
NSWC Dahlgren**



Joint Test & Evaluation Program



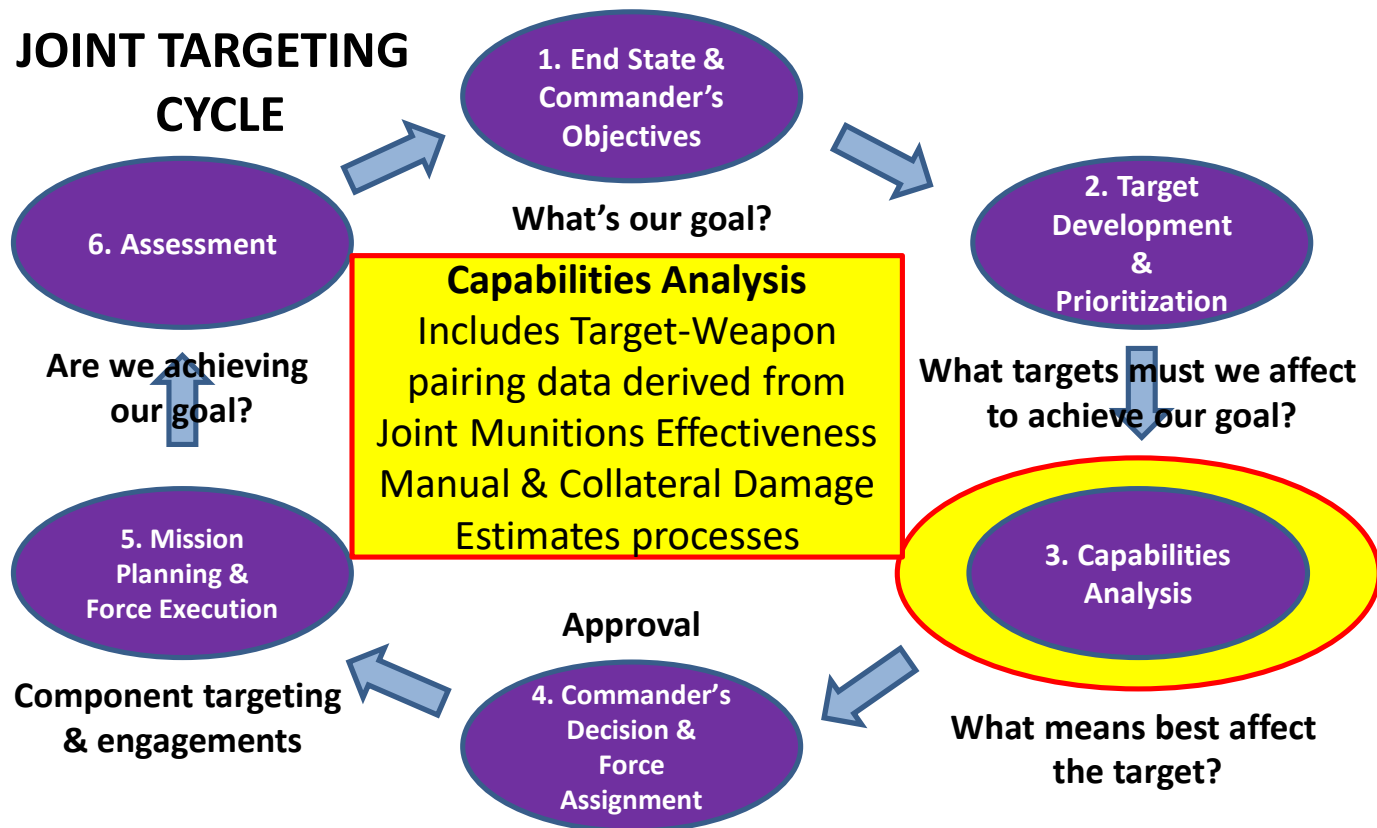
JT&E - Joint Test and Evaluation
QRT - Quick Reaction Test
OTA - Operational Test Agency



JLaSE Problem Statement



Problem Statement: Targeteers lack the ability to incorporate High Energy Laser (HEL) Weapon Systems into the Joint Targeting Cycle, Capabilities Analysis – Weaponneering and Collateral Damage Estimation to employ laser weapon capabilities.





JLaSE Background



- **Proposed as a DOT&E Special Project Joint Test in Aug 2016**
 - **SOCOM initially proposed as lead based on success of the Joint Fiber Laser Mission Engagement (J-FLaME) Joint Test and operational demand for weaponeering/laser lethality**
- **Chartered as Joint Feasibility Study on 24 Feb 2017**
- **Mar 2017, DOD agreed to fund JLaSE and the Joint Technical Coordination Group for Munitions Effectiveness (JTCEG/ME) for FY18/19**
- **Chartered as a Joint Test on 18 Apr 2017 (Two Phases)**
 - **Phase One – 18 Apr 2017 to Dec 2017 to develop the Joint Test**
 - **Phase Two – Jan 2018 to Dec 2019 to conduct the Joint Test**



Operational Endorsers



- USSOCOM
- USMACOM
- USCENTCOM
- NORAD AND NORTHCOM
- USSTRATCOM
- JS J2
- JSOC
- ACC
- OPNAV N94
- MCWL
- USARPAC
- JWAC
- **JTCG/ME signed as Transition Agent & Product Owner**
 - JLaSE will develop and test procedures supporting the HEL Joint Munition Effectiveness Manual (JMEM) Weapon Engineering System (HEL JWS)
- **Also received a Congressional Endorsement**



JLaSE – JTCG/ME Relationship



DOT&E

Deputy Director Air Warfare/JT&E

JLaSE

Joint Targeting Cycle



DOT&E

Deputy Director Live Fire T&E

JTCG/ME



Validated data

Laser JMEM Data



J-NKE
ACC Langley
Mr. Justin Pyle

NSWCDD
Dahlgren
Dr. Chris Lloyd

AFRL
Albuquerque
Mr. Bob Ulibarri

Lethality testing

Lethality testing

AFRL
Ft Sam Houston
Dr. Bob Thomas

SMDC
Huntsville
Mr. Chuck Lamar

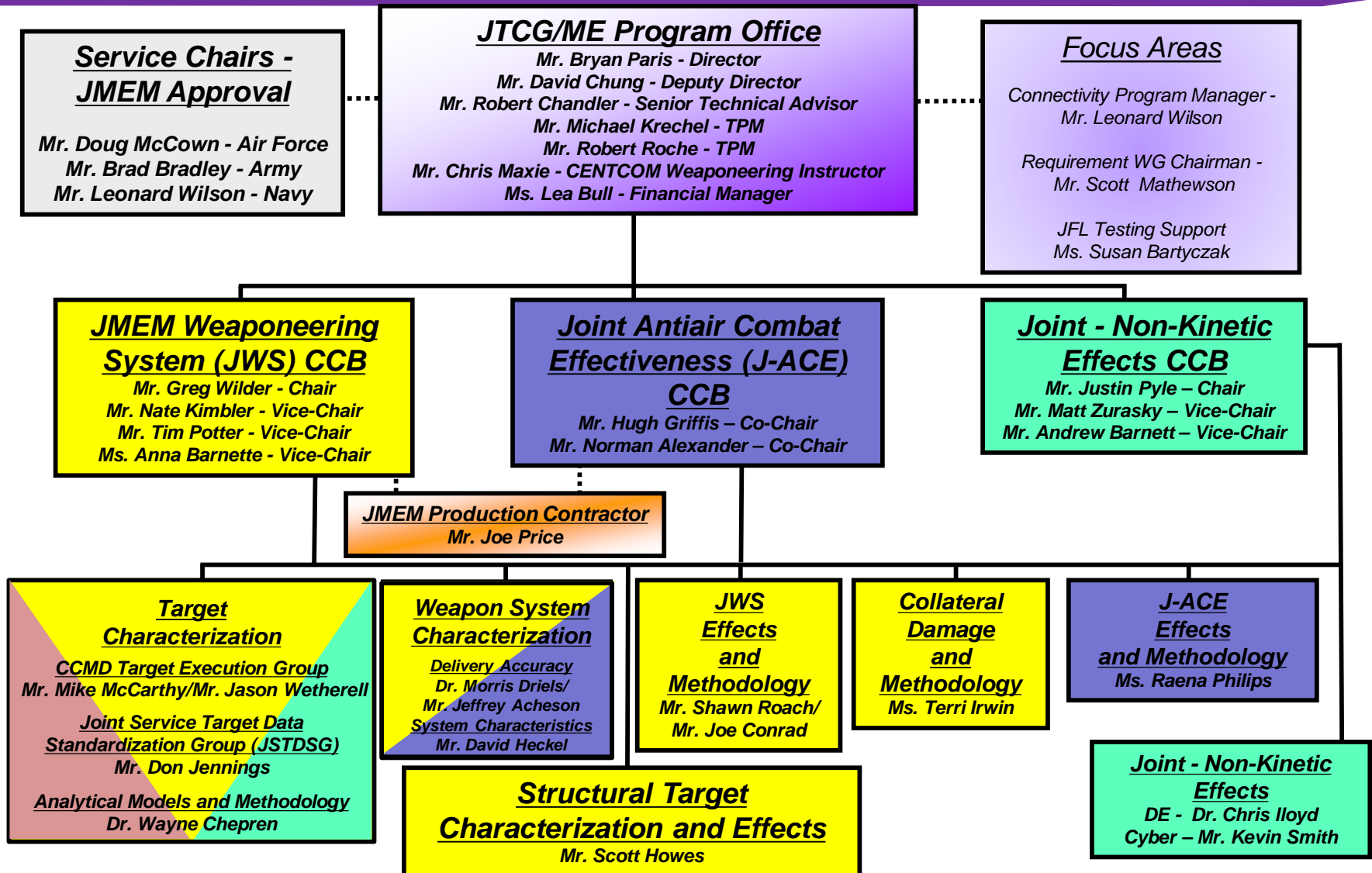
Ocular & Skin CDE

Lethality testing

- JLaSE Joint Test will develop and test procedures using laser JMEM data provided by Joint Non-Kinetic Effects (J-NKE) in support of the JTCG/ME.
- Data from previous, current, and future testing can also be used from NSWCDD & AFRL.



JTCG/ME Organization





Related Directed Energy Efforts



- **Directed Energy Joint Transition Office** (former HEL-JTO)
- **Directed Energy Laser Lethality/M&S efforts** where laser effects and target vulnerability testing are conducted and test results provide inputs into M&S:
 - **Lethality/M&S**
 - ❖ Technical Area Working Group (TAWG) consists of NSWC Dahlgren, Air Force Research Laboratory (AFRL) and the Army Space and Missile Defense Command (SMDC); interaction for over 14 years
 - ❖ The TAWG works with NSWC Crane & AFRL for sensor capabilities expertise in testing of sensors for degradation/damage thresholds
 - **Reflection and Collateral Damage Estimate (CDE)**
 - ❖ AFRL Bio-effects Division in San Antonio conducts HEL reflection testing for input into Hazard Analysis for DE Simulation (HADES) M&S models



Stakeholder Groups



- **Tactics, Techniques, Procedures (TTP) Working Groups (TWG)**: Develop procedures needed to utilize HEL weapon systems and associated data be incorporated into the HEL JWS
- **Intelligence Working Groups (IWG)**: Determine intelligence, weaponeering, and operational processes and products inherent in or to be developed for Capabilities Analysis when employing HEL weapon systems.
- **Joint Warfighters Advisory Groups (JWAG)**: Bring together subject matter experts to represent their organizational operational perspectives.



General Officer Steering Committee



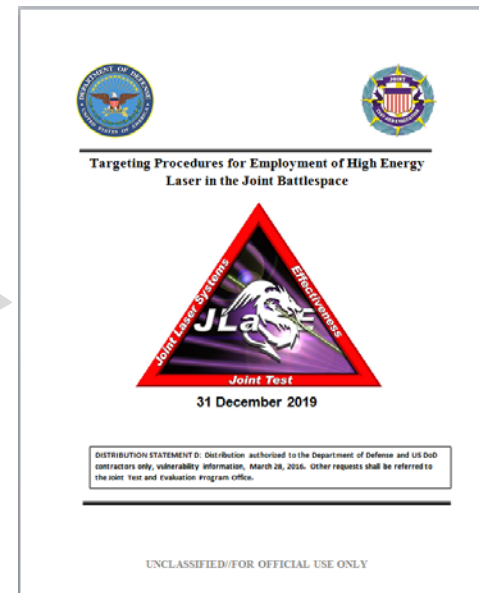
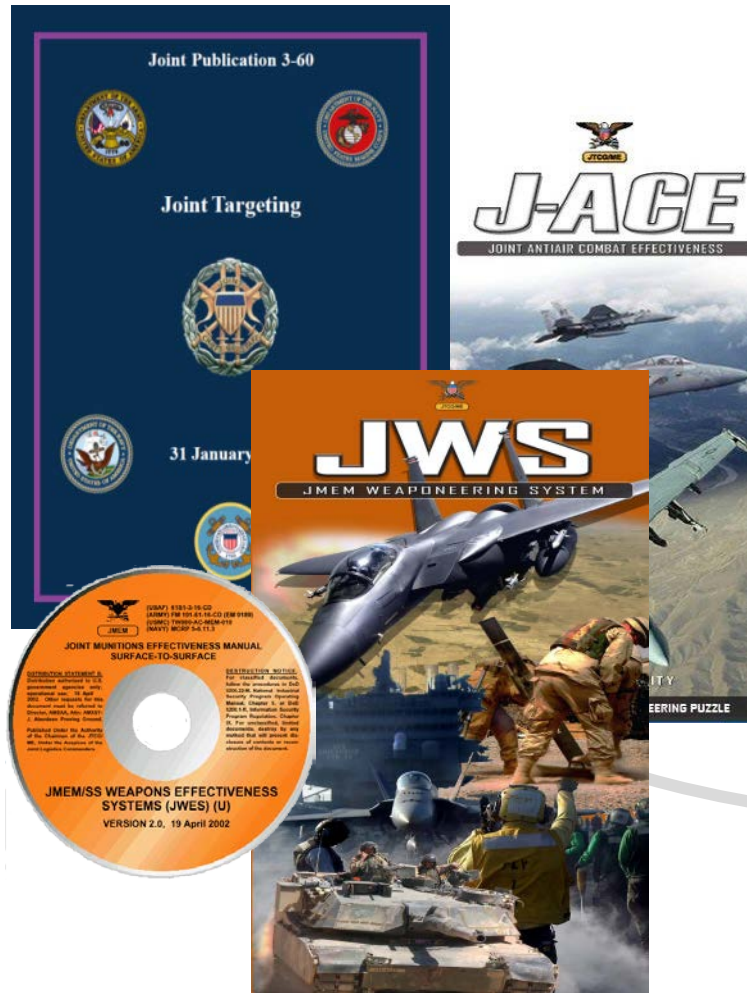
Members		
Chair	RADM Hahn	Chief of Naval Research
DOT&E	Mr. Crisp (SES)	Deputy Director Air Warfare
DOT&E	Dr. Ugrina (SES)	Deputy Director Live Fire T&E
OSD Policy	Mr. Colby (SES)	DASD Strategy & Force Dev
OUSD AT&L	Dr. Conley (SES)	Deputy Director Electronic Warfare
USD(I)	Lt Gen Shanahan	Director for Defense Intelligence
ASD SO/LIC	Mr. Bob Doheny (SES)	Sr. Advisor for Policy and Program Oversight
SOCOM	Mr. Smith (SES)	Deputy Director Special Operations Research
PACOM	Dr. Ka'iliwai (SES)	Director Resources and Assessments J8
EUCOM	MG Davis / Brig Gen Meyer	Director of Operations J3
NORTHCOM	RDML Bert / BG Kramer	Deputy Director of Operations J3
NORAD	Brig Gen Pierce/Brig Gen Huyck	Deputy Director of Operations J3
US Air Force	Mr. Ted Uchida (SES)	Deputy Director ACC A3/ACC/A3-2
US Marine Corps	BGen Wortman	CG MCWL / VCNR
US Army	MG Shoffner	CG Fires Center of Excellence
US Navy	RDML Small	NAVSEA PEO IWS 2



Test Article Development Weaponneering and CDE Processes



- JLaSE will:
 - Integrate HEL capabilities into existing joint weaponneering processes
 - Gain consensus from JWAG/GOSC selecting target (e.g. vehicles, UAS, small boats, power/comm grids)
 - Reverse engineer of JTCG system processes (e.g. JMEM Weaponneering System (JWS), Joint Anti-Air Combat Effectiveness (J-ACE), and Collateral Damage Estimate Mitigation Methodology Tools





Field Test and TTP Development Events (TDE)



TDE	Test Venue	Location	Time Frame
TDE 1	MAWTS-1	Yuma, AZ	10-17 Apr 2018
TDE 2 (AW)	NAWDC	NAS Fallon, NV	Jun 2018
TDE 2 (SW)	SMWDC	Dahlgren, VA	Sep 2018
TDE 3	SOF	Ft Bragg, NC	Oct 2018
TDE 4	USAF/ Navy SOF	Hurlburt Field, FL / Canon AFB, NM	Jan 2019
Field Test A	JS J6 C5 AD	Suffolk, VA	Feb-Mar 2019
Field Test B	TS 2019	PACOM Exercises	2019
FT-B Back Up	NE 2019	PACOM Exercises	2019

- MAWTS-1 – Marine Aviation Weapons and Tactics Squadron One
- NAWDC – Naval Aviation Warfighting Development Center
- SMWDC – Surface & Mine Warfare Development Center
- USAF – United States Air Force
- SOF –Special Operations Forces
- JS J6 C5 AD – Joint Staff J6 C5 Assessments Div
- TS – TALISMAN SABRE
- NE – NORTHERN EDGE



End State - Test Product



Targeting Procedures for Employment of High Energy Laser in the Joint Battlespace



31 December 2019

DISTRIBUTION STATEMENT D: Distribution authorized to the Department of Defense and US DoD contractors only, vulnerability information, March 28, 2016. Other requests shall be referred to the Joint Test and Evaluation Program Office.

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Table of Contents

Executive Summary

Chapter 1 – Introduction

1. HEL Overview
2. Joint Targeting Cycle

Chapter 2 – Targeting Considerations For HEL

Chapter 3 – Capability Analysis Procedures For HEL

1. Target Vulnerability Analysis
 - Identify Collection Requirements
 - Analyze Target Elements
 - Determine Damage Criteria
 - Determine Desired Probability of Damage
2. Effects Estimate
 - Calculate Weapons Effectiveness
 - Select Point of Attack
 - Perform Collateral Damage Estimation
3. Consolidated Target development, BDA, and CDE
 - Consolidate Target Development
 - Consolidate Battle Damage Assessment Collection Requirements
 - Consolidate Collateral Damage Estimate

Appendix A – Air-to-Surface Checklist

Appendix B – Surface-to-Surface Checklist

Appendix C – Surface-to-Air Checklist

Appendix D – Air-to-Air Checklist

3rd Directed Energy Systems Summit



High Energy Laser Technology for the Multi-domain Battlefield

Mr. Thomas E. Webber, SES
Director,
Technical Center



USASMDC/ARSTRAT



Senior Commander



JFCC IMD



1st Space
Brigade



100th Missile Defense
Brigade (GMD)



Future Warfare
Center



Technical
Center

USASMDC/ARSTRAT Mission

Develops and provides current and future global space, missile defense, and high altitude capabilities to the Army, Joint Force, and our Allies and partners, to enable multi-domain combat effects; enhance deterrence, assurance, and detection of strategic attacks; and protect the Nation.

Priorities

- Protect our Homeland
- Provide combat-ready forces and capabilities
- Plan and conduct synchronized global operations
- Prepare or adopt leap-ahead concepts and technologies
- Preserve and account for the Nation's critical resources
- Promote and foster a positive command climate

Mission Areas

ASCC/Operational Support

Service Activities

Army Proponency

Other CG Roles & Responsibilities

- Commander, Joint Functional Component Command for Integrated Missile Defense (JFCC IMD)
- Senior Commander for U.S. Army Garrison - Kwajalein Atoll and Fort Greely, Alaska
- Army Air and Missile Defense Enterprise Integrator
- Personnel Developer, Functional Area 40 Space Operations Officers

USASMDC/ARSTRAT



- **The Army Recognizes value of High Energy Laser**
- **USASMD/ARSTRAT is Army lead for High Energy Laser Science & Technology**
- **USASMD/ARSTRAT collaborating to ensure Integration**

USASMD/ARSTRAT's High Energy Laser Role

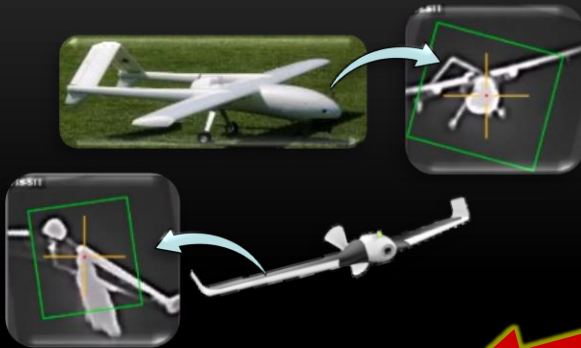
HELMTT

Joint Improvised-threat Defeat Organization (JIDO) Hard-kill Challenge

System Name	Phase I Points	Phase II Points	Phase III Points	Total Points
High Energy Laser Mobile Test Truck (HELMTT)	637	622	722	1981
Mobile High Energy Laser (MEHEL)	555	147	28	730



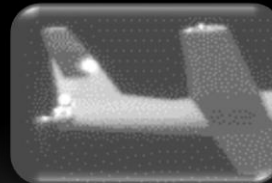
MEHEL
2.0



Unmanned Aerial System
Engagements



Maneuver Fires Integration Experiment
(MFIx)



Multiple
Engagements Types



Past High Energy Laser Demonstrations

Ground mobile platform development - integrated Beam Control System (BCS) on Heavy Expanded Mobility Tactical Truck (HEMTT)

- High Energy Laser Technology Demonstrator



Integrate 10kW commercial laser, thermal management, and power on HEMTT

- High Energy Laser Technology Demonstrator (HEL MD)

Lessons Learned

Integrate 60 kW laser on HEMTT

- High Energy Laser Mobile Test Truck (HELMTT)

Integrate 100 kW laser, compact thermal/power, and advanced BCS on Family of Medium Tactical Vehicles

- High Energy Laser Tactical Vehicle Demonstrator (HEL TVD)



Transition technology to Program of Record

- Initial Operational Capability Indirect Fires
Protection Capability Increment 2, Block 2

Integrate 5 kW laser on Stryker

- Mobile Experimental High Energy Laser (MEHEL)



Integrate 50 kW laser on Stryker

- Multi-Mission High Energy Laser (MMHEL)



Transition technology to Program of Record

- Maneuver-Short Range Air Defense

Army Path to High Energy Laser Weapon Systems

Capabilities Development Document for the Indirect Fires Protection Capability



FMTV-based



FCoE



Stryker-based



ASA(ALT)

Technology to Transition

HEL TVD
100 kW Demo

PEO MS

Data to Inform Requirements

MMHEL
Demonstration



SMDC

HELMTT
50 kW Demo



MEHEL



TTP & CONOPS

Initial Capabilities Document For Maneuver Short Range Air Defense Capability



HEL Weapon System Development and Transition

HELMTT

Provides key
knowledge
points for
HEL TVD



Key Events

- ✓ FY14 – 10 kW System Demonstration
 - ✓ FY16 – Maneuver Fires Integration Exercise
 - ✓ FY17 – Hard-Kill Challenge
 - ✓ FY18 – 50 kW-class Integration
 - ▶ FY18 – 50 kW-class Demonstration

High Energy Laser Mobile Test Truck (HELMTT)

HEL TVD

Demonstrate a mobile HEL system on a tactical platform that defeats
Rockets, Artillery, and Mortars (RAM)
and Unmanned Aerial Systems (UAS)



Payoff

- Flexible response to RAM and UAS threats
- Low-cost engagements
- Deep magazine

High Energy Laser Tactical Vehicle Demonstrator (HEL TVD)

“We are at the beginning of a next generation of warfare, where we use less kinetic means and instead put energy on a target. It’s brilliant. It’s limited only on your power source, and in the future, it could have almost unlimited potential.”

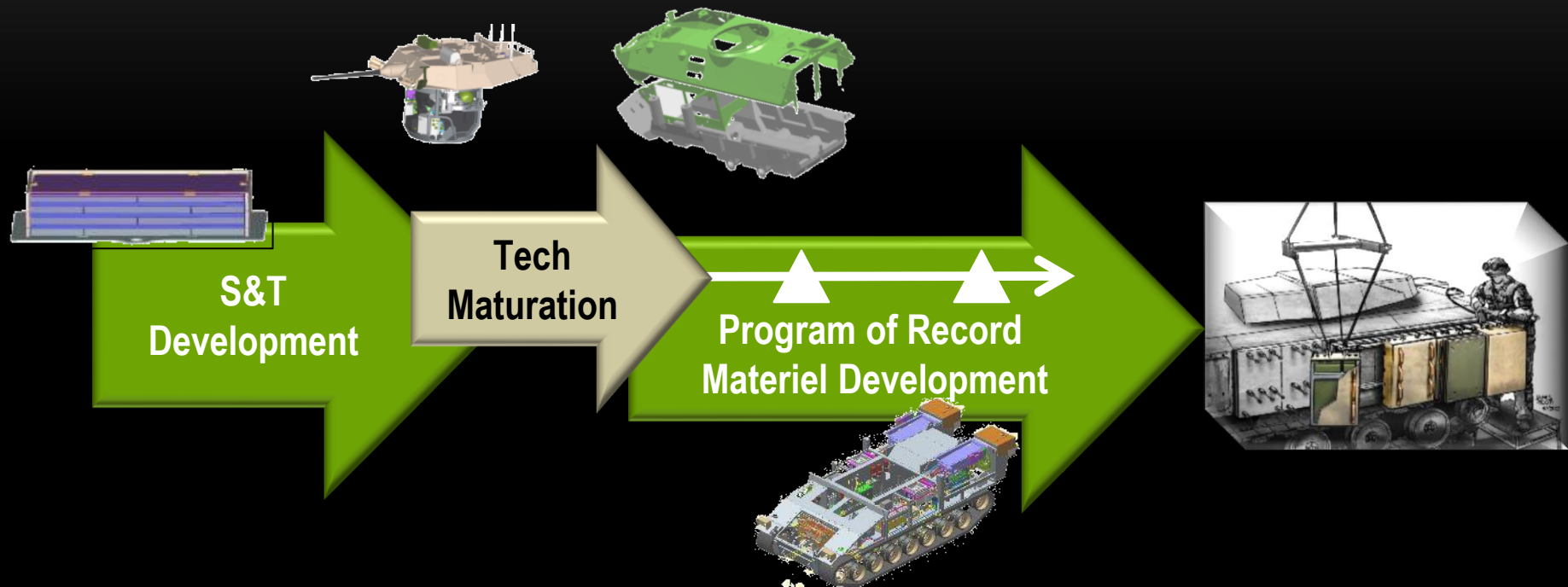
JWA Spokesman



Joint Warfighting Assessment (JWA)

Mobile Experimental High Energy Laser (MEHEL)

- Mature Key Capabilities The Army Needs
- Apply When And Where Appropriate To “Ramp Up” Technology Insertion



- Experimental Prototyping In Advance Of Requirement For Future Army Program Of Record
- Developmental Prototyping To Inform Enhanced Requirements

Technology Maturation Initiative

Technology Maturation Initiative



MMHEL

Demonstrate a 50 kW-class combat-platform-based system that can maneuver with Brigade Combat Teams to defeat UAS, RAM and ISR threats

Multi-Mission High Energy Laser (MMHEL)

- 
- Path To Transition Technology
 - HELMTT Provides Key Knowledge Points
 - HEL TVD Demonstrates A Mobile HEL System
 - MEHEL Informs TTPs And CONOPS
 - MMHEL Technology Maturation Initiative
 - Recent Experiments Demonstrate Progress

Summary



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US Special Operations Command



AC-130J Airborne High Energy Laser Demonstration

Lt Col Oluyomi “Yomi” Faminu

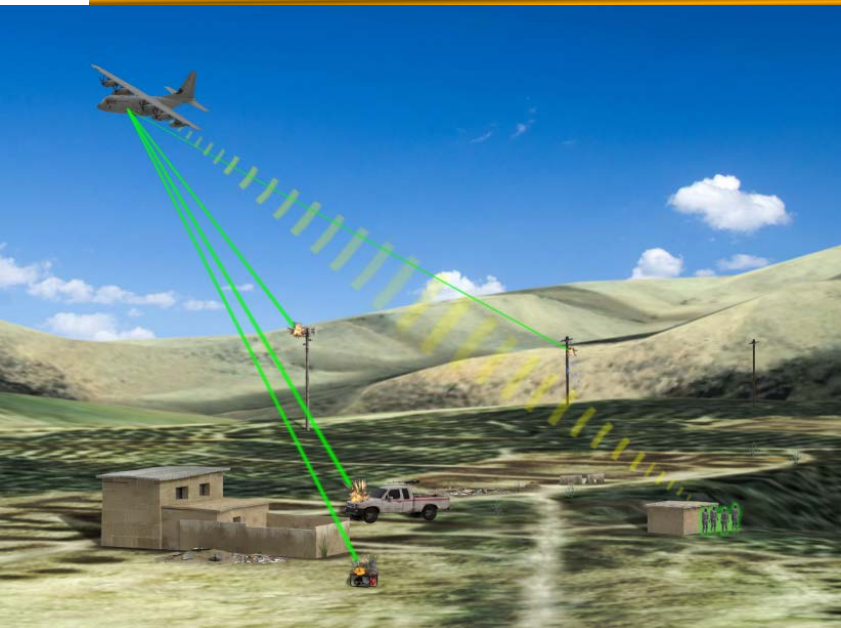
**Division Chief, Technology Insertion Division
USSOCOM Program Executive Office-Fixed Wing**

Distribution Statement A: Approved for public release; distribution unlimited.

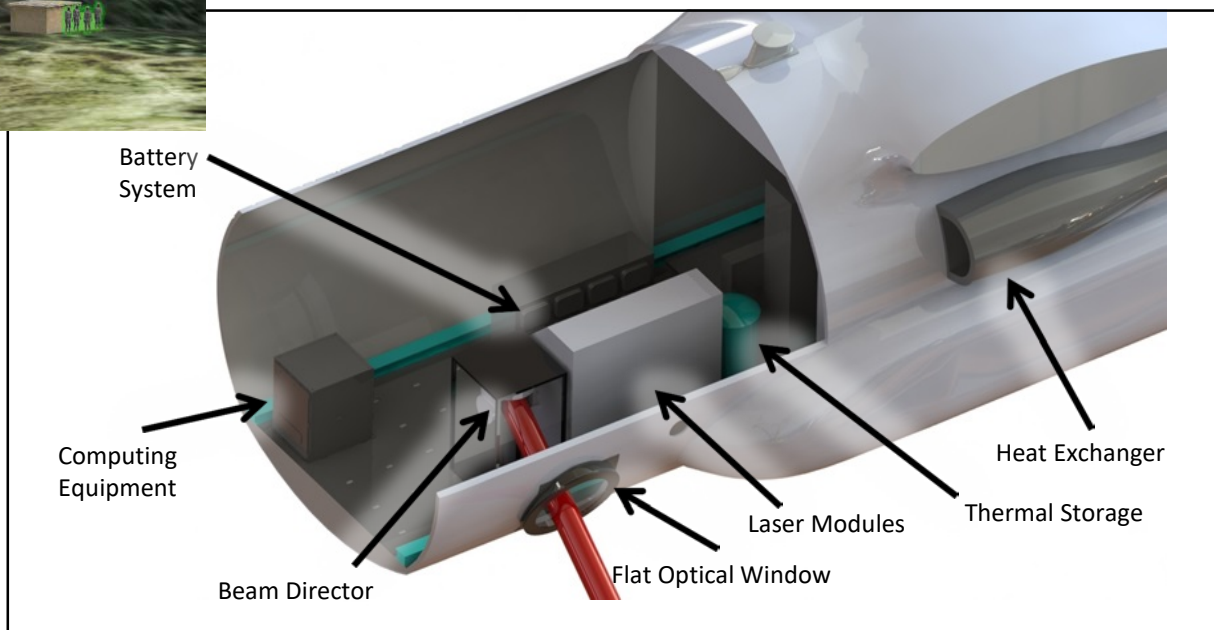
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High Energy Laser (HEL) Concept



High Energy Laser from a AC-130J operating at operationally relevant altitude from the 30mm gun footprint

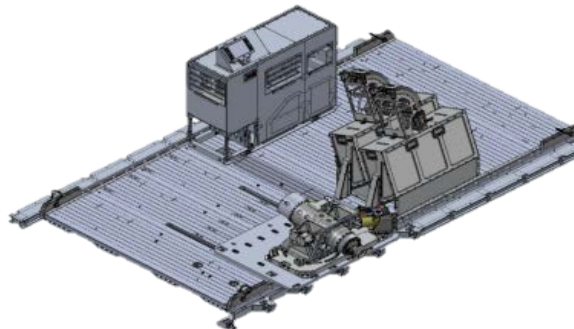




60 kW Prototype Trade Space

Parameter	CONOP Value		
Size	No larger than 30mm pallet		
	Threshold	Objective	
Weight	6600 lb	5000 lb	
Altitude	10,000 ft	20,000 ft	
Duty Cycle	600 sec No Recharge	180 Sec 10 %	60 Sec 25%
Fire Control	Integrate seamlessly into BMS* and PSP**		

*Total 30mm GWS Weight:
5000 lbs - w/o ammo
6600 lbs – full ammo load out*



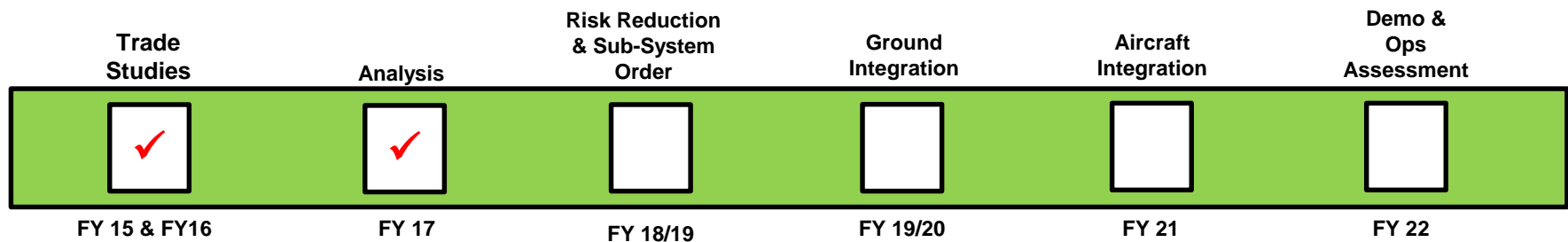
*BMS: Battle Management Sys

**PSP: Precision Strike Package



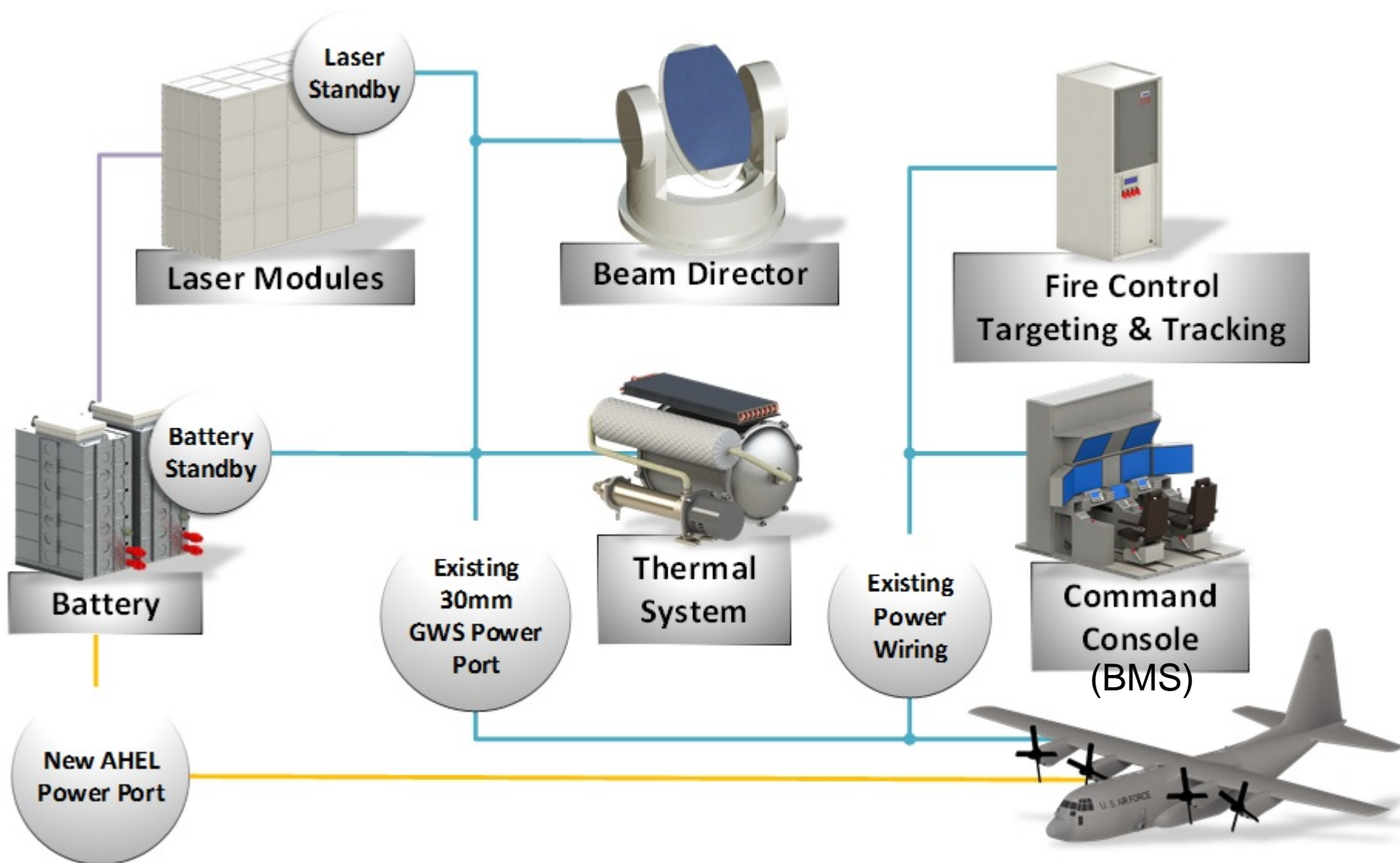
High Energy Laser Background

- **Program Goal:** Demonstrate a precise airborne low kinetic weapon system capable of targeting in complex environments and ground based scalable effects on an AC-130J
- Completed trade studies and analysis
- Risk reduction activities initiated & Sub system order underway
- Integrate “best of breed” sub-systems with 60 kW Prototype





60 kW Prototype Sub-Systems



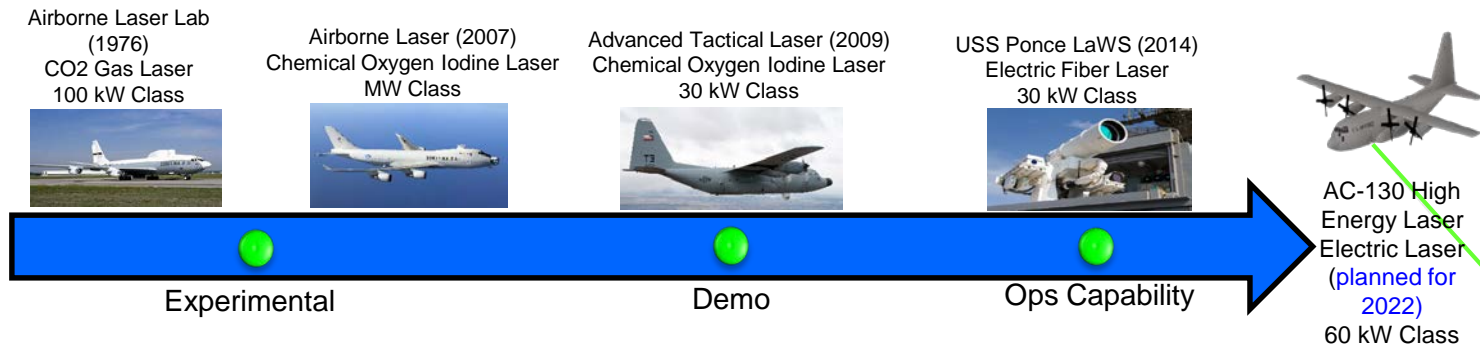


Acquisition Approach

- USG lead system integrator - Naval Surface Warfare Center Dahlgren Division
 - Provides flexibility for future system modifications/upgrades
- Leverage existing DoD Ordnance Technology Consortium proposals for “best of breed” sub-system purchases
 - Sub-systems identified & ready for agreement execution
- Develop capability leveraging use of DoD owned resources & facilities
 - Integrate with existing AC-130J fire control infrastructure
 - AFSOC provided aircraft, aircrew & maintenance
 - Utilize test hardware across DoD Directed Energy community



Lessons Learned/Risk Mitigation

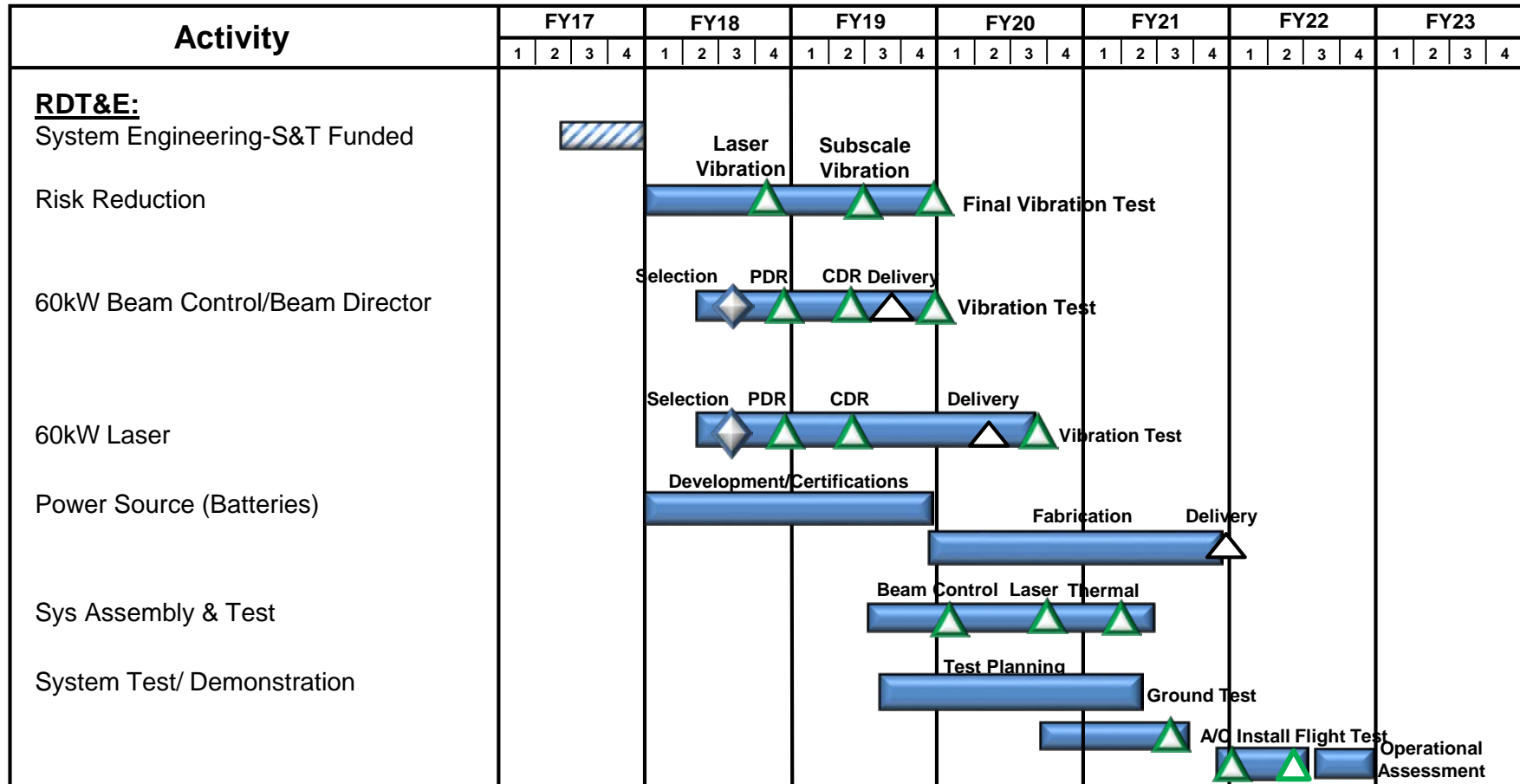


- Incorporating prior airborne laser lessons learned to inform risk reduction efforts
- Minimization of Aero-Mechanical & Aero Optical effects due to air stream (ABL, ATL)
 - Perform CFD analysis utilizing AC-130J lase scan data
 - Aero-Optic Flight characterization with surrogate window
- Minimization/management of beam jitter induced by dynamic Flt environment (ABL, ATL)
 - Compare flight vibration data to ELTF results
 - Test low power laser at post-isolation vibration & acoustic profile
- Performance of electric lasers at altitude (SWAP: Chemical (ABL) & (ATL) → Electric)
 - Vibration test of low power Spectral Beam Combined laser post-isolation



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AC-130 High Energy Laser Schedule



A/C Install Flight Test Operational Assessment

As of 5 Jun 2018

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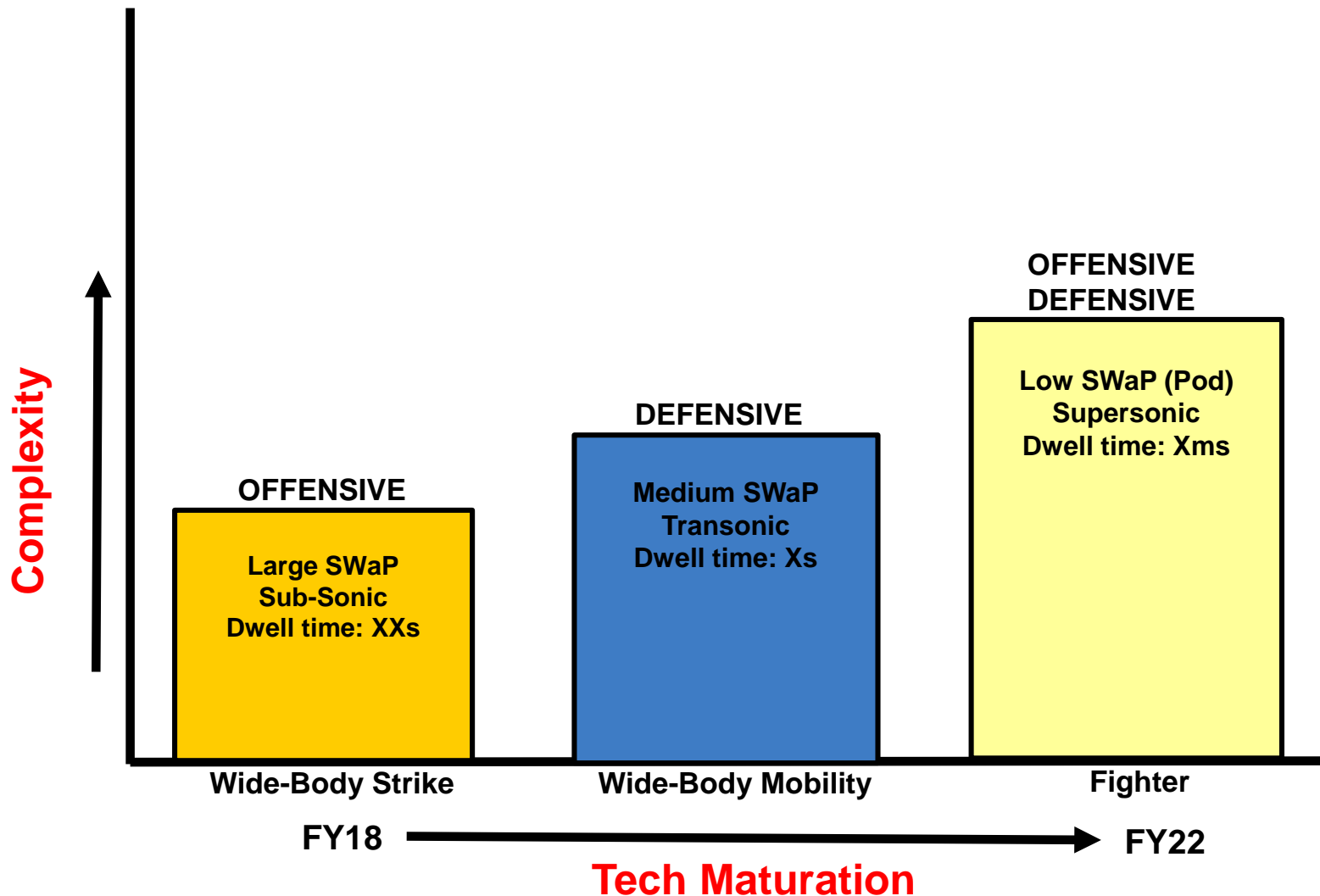


Conclusion

- AC-130J 60 kW High Energy Laser is a next generation weapon system capable of providing scalable effects in complex targeting environments with low acoustic & kinetic signatures
- Mitigate risks identified from prior HEL projects
- Government Lead System Integrator provides flexibility for future modifications and upgrades
- Prototype demonstration planned for FY22



Airborne HEL Development



Energy Magazines for Directed Energy Weapons and Back-up Power

IQPC Directed Energy Summit 2018

Don Klick, Leonardo DRS Naval Power Systems,
Director Business Development

June 27, 2018

Carlos Aguirre, Leonardo DRS Land Electronics,
Senior Manager Business Development



Leonardo: We Are A Global Company

More than 218 Sites Worldwide*

TOTAL WORKFORCE	47,156
ITALY	29,853
UNITED KINGDOM	7,321
USA	5,969
POLAND	3,043
REST OF THE WORLD	970



A Leading Global Partner for Defense, Aerospace & Security Solutions

*Industrial Legal Entities, Partnerships (JVs-Consortia), Branch and Representative Offices Shown.

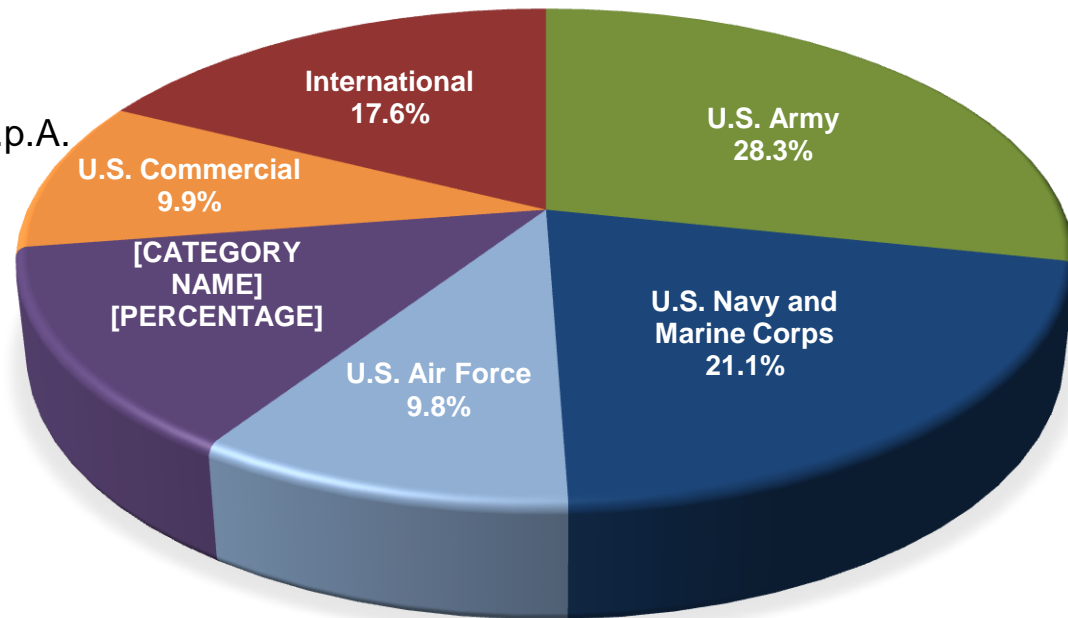


An Overview of Leonardo DRS



A leading technology innovator and supplier of integrated products, services and support to military forces, intelligence agencies and prime contractors worldwide

- A wholly owned subsidiary of Leonardo S.p.A.
- Headquartered in Arlington, Virginia
- \$2B+ Revenue
- We are organized into eight customer-focused lines of business
 - Airborne and Intelligence Systems
 - Daylight Solutions
 - Electro-Optical and Infrared Systems
 - Global Communications and Security
 - Land Electronics
 - Land Systems
 - Naval Electronics
 - Naval Power Systems

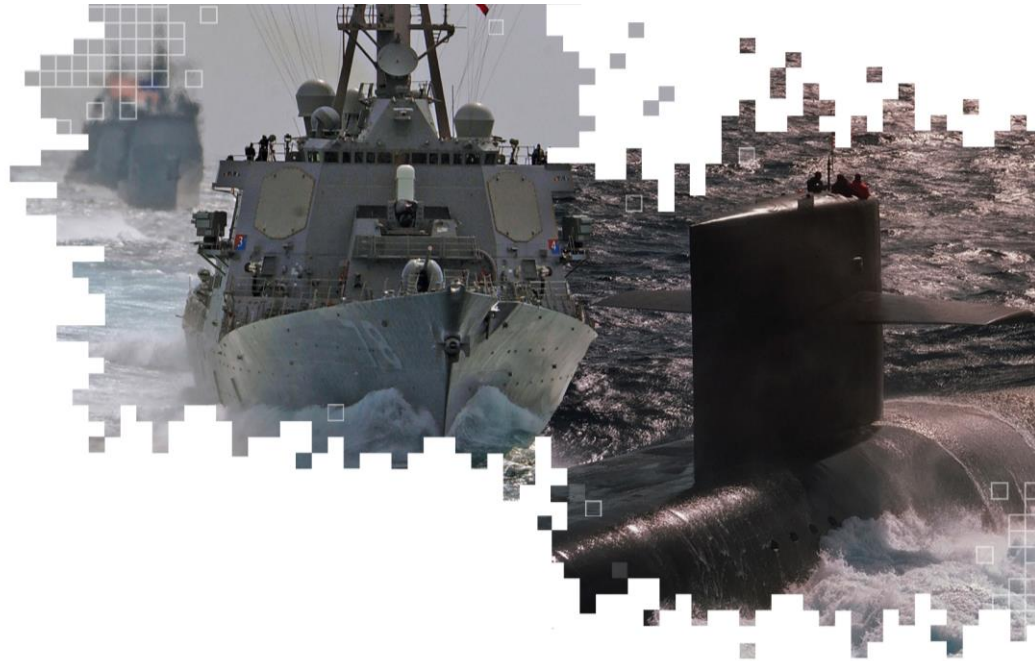


**2015 – 2019
Business Mix By Customer**

Naval Power Systems

As a trusted provider of naval power and control technology we deliver quality, customer-focused products and support solutions for the U.S. Navy and our allies. Our products meet stringent specifications and have been proven to perform in harsh marine environments.

We also provide power & control solutions for other applications including power plants, oil and gas drilling, and electric vehicles.



Milwaukee, WI



Power Conversion, Control & Distribution

Power storage, low & medium voltage power distribution and modular power solutions for ship & submarine platforms

Danbury, CT



Naval Nuclear Instrumented Control Systems

Trusted provider of critical naval instrumentation and controls for nuclear submarines & aircraft carriers

Fitchburg, MA



Machines for Electric & Hybrid Electric Platforms

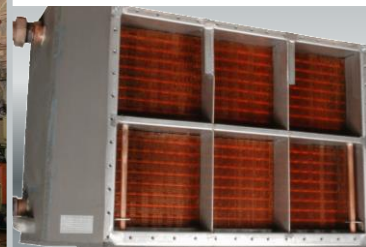
Motors, generators & drives for demanding applications ranging from small pump motors to 36.5 MW PM ship propulsion motors

High Ridge, MO



Gas Turbine Packaging

As a full-service equipment packager we have provided packaging for major engine manufacturers for service in naval and ground power applications around the world



HVAC & Refrigeration

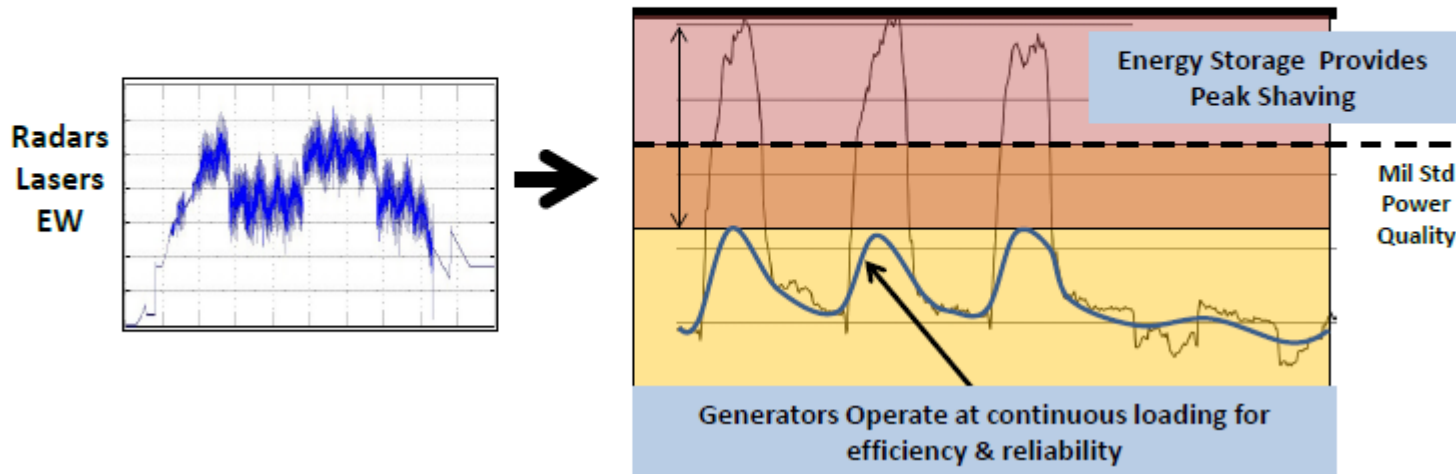
One of the U.S. Navy's largest suppliers of shipboard heating / cooling coils, air handling units, product coolers and refrigeration plants



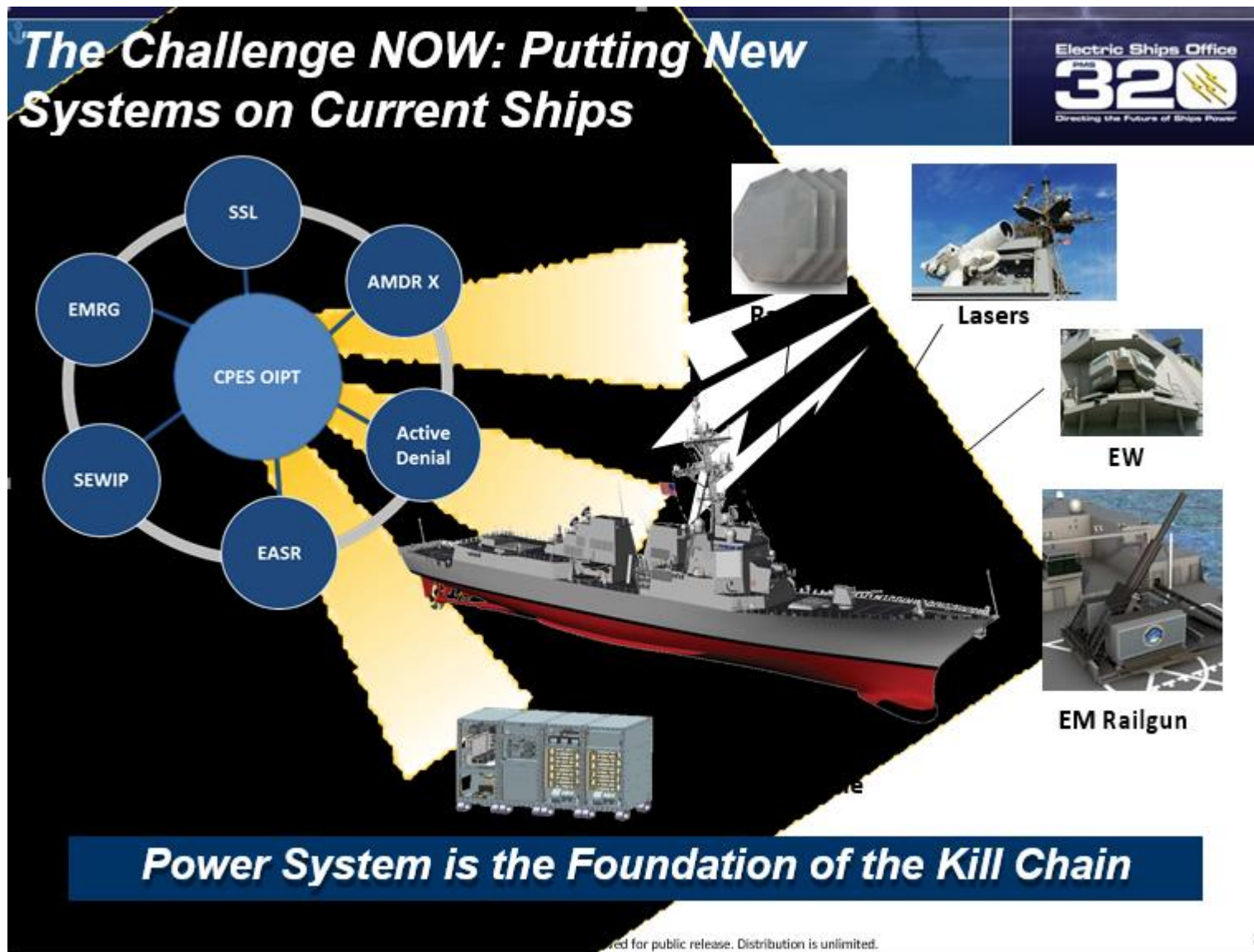
Navy Directed Energy Weapons: Need for Energy Magazines

- Ship electrical generators source pulse loads < 2 MW/second per MIL-STD-1399
- Directed Energy Weapons and Sensors provided power at 650 VDC
- Multiple high-power DE weapons and sensors create a stochastic composite load profile:

***The Power System Challenge NOW:
Support High Power Mission Systems***



Energy Magazines for Current US Navy Ships



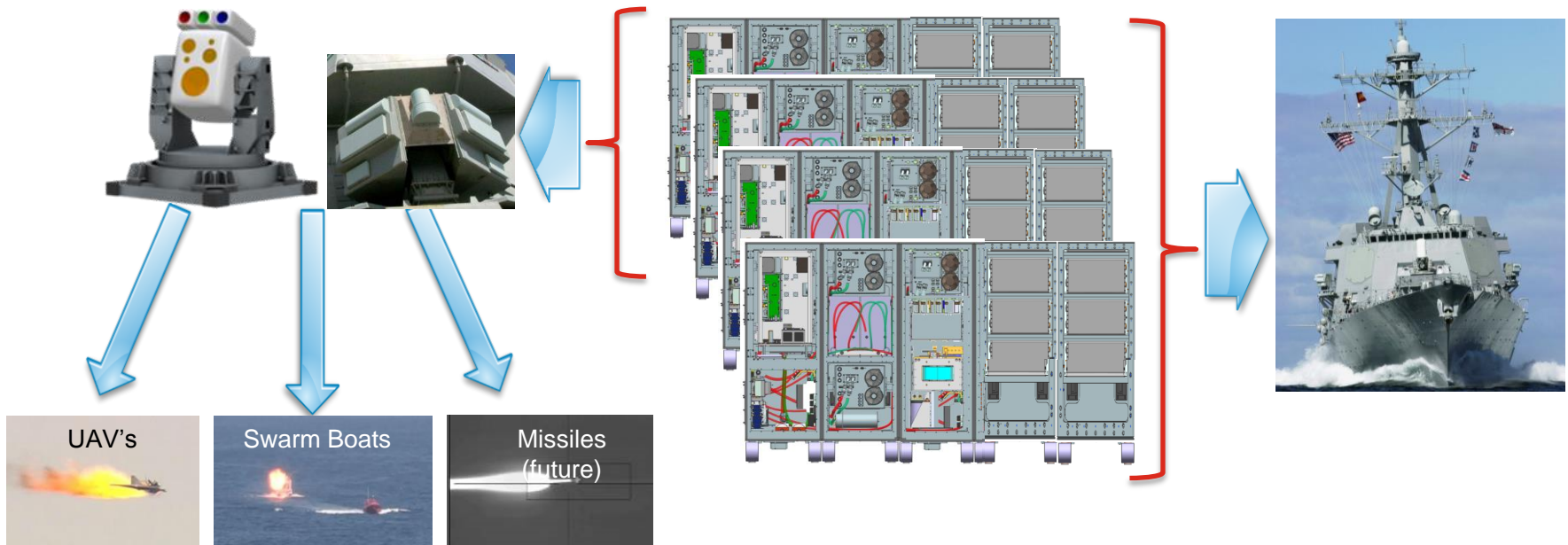
DDG 51 Energy Magazine – Modular, Multi-output, Cabinets

Pulsed Power Weapons/Sensors

- Lasers
- SEWIP
- Radars

Ship Stable Backup Power:

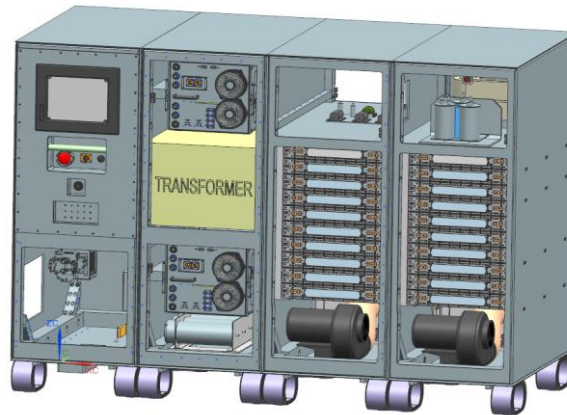
- Single Generator Operations
- Peak Shaving



Energy Magazine-Laser Prototype Demonstrator

Energy Magazine Capability:

- 660kW of 650 VDC, galvanically isolated output; 50% five second duty cycle for 4 minutes
- Air-Cooled LFP batteries
- Recharge to full power in 53 minutes with 450VAC power input



- Successfully validation tested at DRS September 2017
- Shipped to US Navy at FSU CAPS for system testing
 - Successfully completed November 2017
 - Navy demonstration test completed January 2018

Proven capability for ship installation

Energy Magazine Evolution

EM-Laser

LFP Batteries

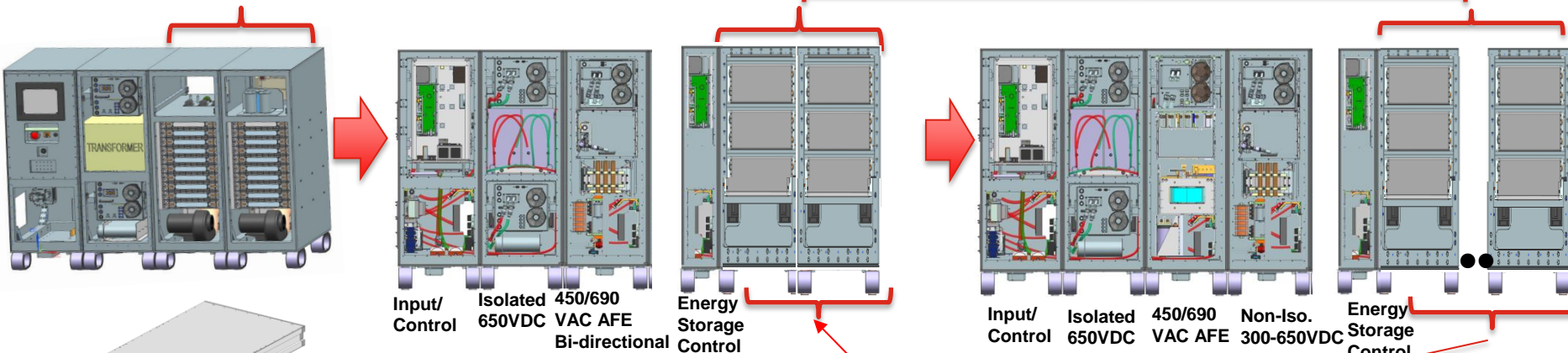
- 1000 VDC output (dual stacks)
- Air Cooled Design
- 71 kW-hr (256MJ) total

EM-Laser Plus

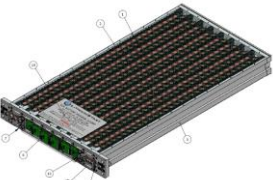
LFP Batteries

- 1000 VDC output in each stack
- Liquid Cooled Design
- 71 kW-hr (256MJ)

EM-Mark II



Control Drawers: 70 lbs



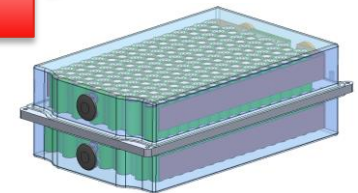
Battery Drawers: 105 lbs
18 @ 16S30P

**EaglePicher™
Technologies, LLC**

Design Compliant to:

- MIL-STD-1399, Section 300B, Input Power Quality
- MIL-STD-167-1, Type I, Vibration
- MIL-STD-741-1 Airborne Noise
- MIL-STD-741-2 Structure-borne Noise, Type III
- MIL-STD-461F, EMI
- DDS-072-1/ -5, Grade A Shock
- DOD-STD-1399-70-1 Magnetic DC Field
- NEMA IEC 60529, IP54 Enclosure
- NAVSEA S9310-AQ-SAF-010/ SG270-BV-SAF-010
- DOD Directive 8500.01/02 Information Assurance Options

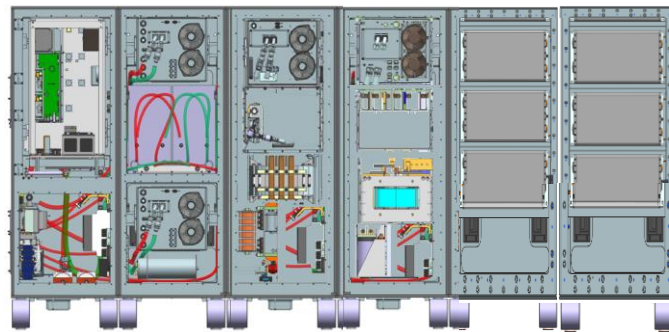
**Hybrid Storage Options:
Capacitors, Batteries**



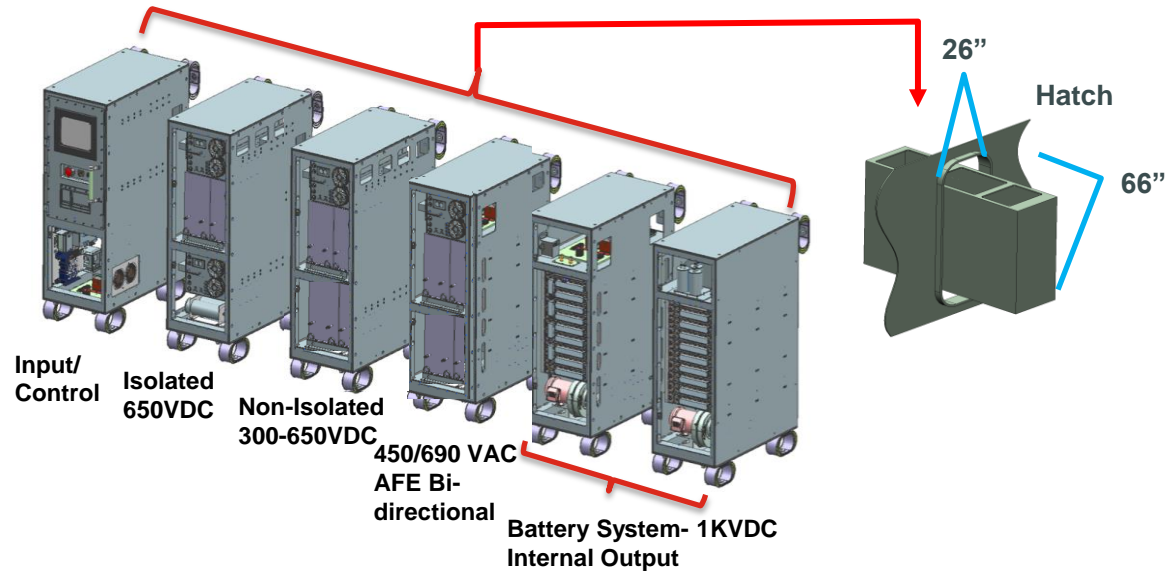
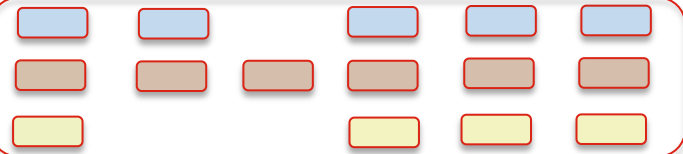
Battery Modules: 120 lbs
24 @ 24S16P


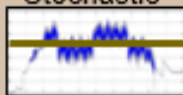
**EaglePicher™
Technologies, LLC**

Energy Magazine: Modular, Hatch-able, Adaptable

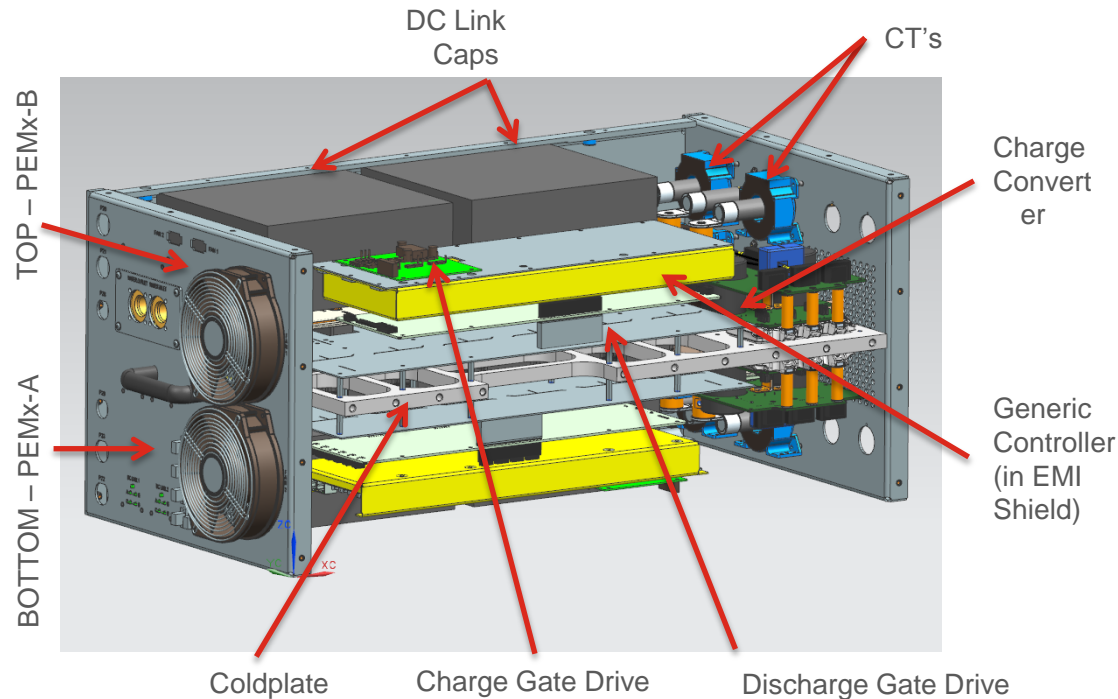


Application Chart



	Power / Duration	Duty Cycle	Recharge Time	Output Voltage	Discharge Cycles	Galvanic Isolation	Cabinet Size
EM-Pulse Power-Limited	660kW / 4 Minutes	Notional 50% 	< 15 min (10 Min.)	650VDC Galvanic Isolation	>1000	AC-DC; DC-AC	48" D x 66" H x 125" W
EM-Pulse Power-Continuous	900kW / Continuous	Stochastic 	Continuous	650VDC; Isolated & Non-isolated	N/A	AC-DC; DC-AC	48" D x 66" H x 150" W
EM-Stable Backup Power	750kW / 3 Min.	100% Continuous	< 15 min. (10 Min.)	450/690 VAC, 60 Hz	> 250	AC-DC; DC-AC	48" D x 66" H x 125" W

Power Electronic Module (PEM) Model: Dual Power Module



Redundant Power Modules @ 450kW each: 900 kW total @ 440Vac

Redundant power module: building block for critical mission weapons

Land Electronics

Leonardo DRS provides world class cyber hardened network & tactical computing for C4I and integrated situational awareness. Provides state of the art embedded diagnostics, vehicle power management and combat vehicle integration products and services.

- Cyber Secure Network & Tactical Computing Solutions
- Battlefield Management & Situational Awareness
- Vehicle integrated Test & Diagnostics
- Depot Level Test & Diagnostics
- Power Generation, Distribution & Management
- Avionics/EW Test Equipment



Huntsville, AL



Platform Computing

Integrated computer & display systems for enhanced SA on the battlefield



Platform Electronics

Integrated Mission Systems for enhanced situational awareness on the battlefield



Test & Diagnostics

Diagnostic & data acquisition systems for domestic and foreign combat vehicles



Operational Energy

Providing tactical battlefield power, when and where it is needed

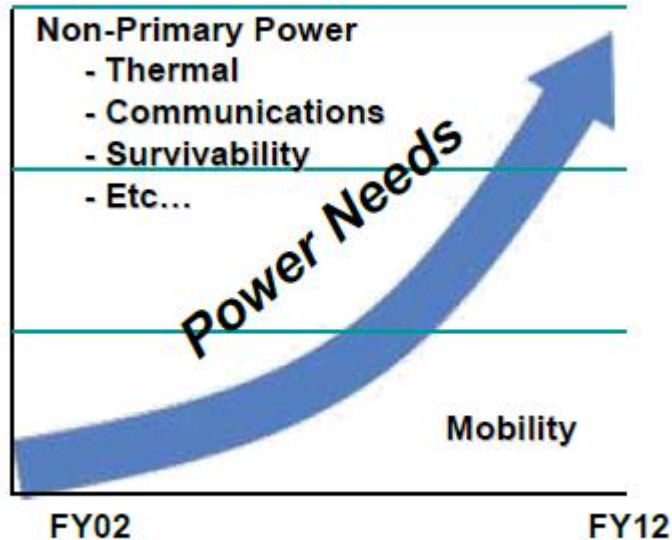


Flight Line Equipment

Providing verification of installed Electronic Warfare equipment at factory and prior to mission

Joint Light Tactical Vehicle Power Requirements Study

24 April 2007



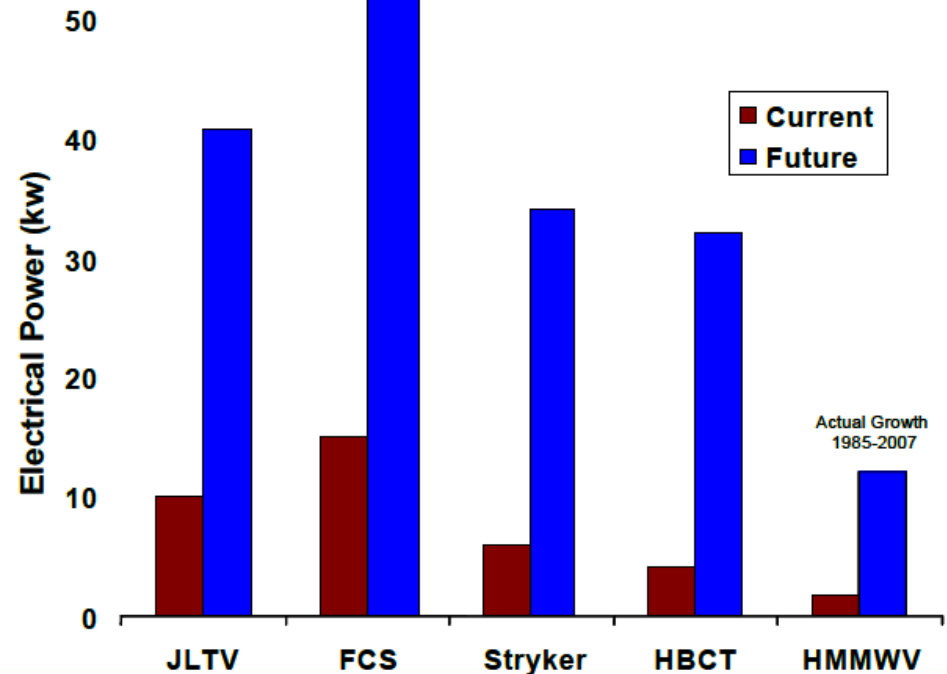
THEN

Ms. Jennifer Hitchcock
Associate Director of Ground Vehicle Power and
Mobility TARDEC

NOW

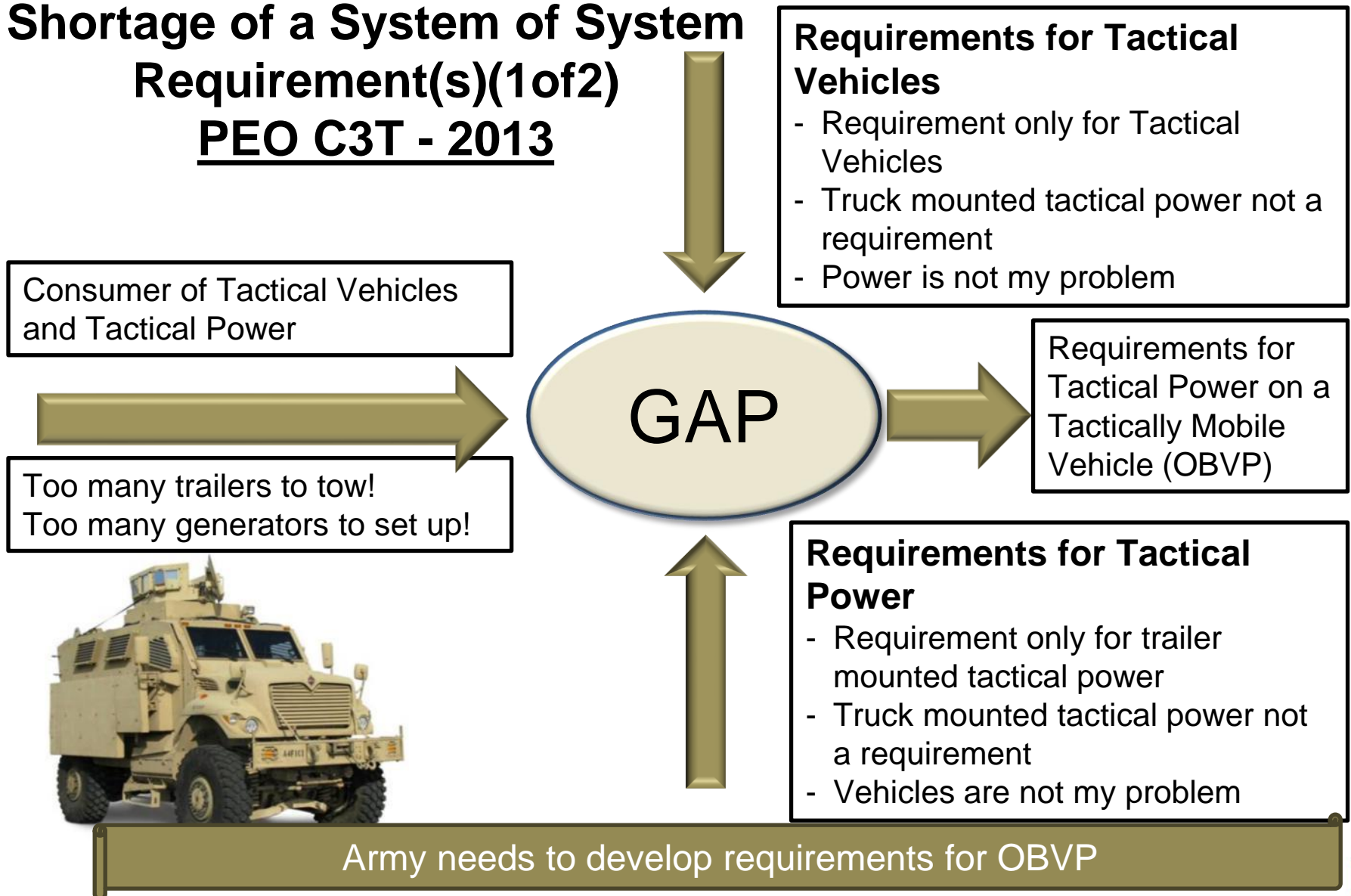
Dr. Jennifer Hitchcock, SES
Executive Director, Research, Technology &
Integration
TARDEC

Non-Primary Power Estimated Electrical Power Growth



Shortage of a System of System Requirement(s)(1 of 2)

PEO C3T - 2013



Combat Vehicle Power Gap

19 January 2017

POSITION PAPER

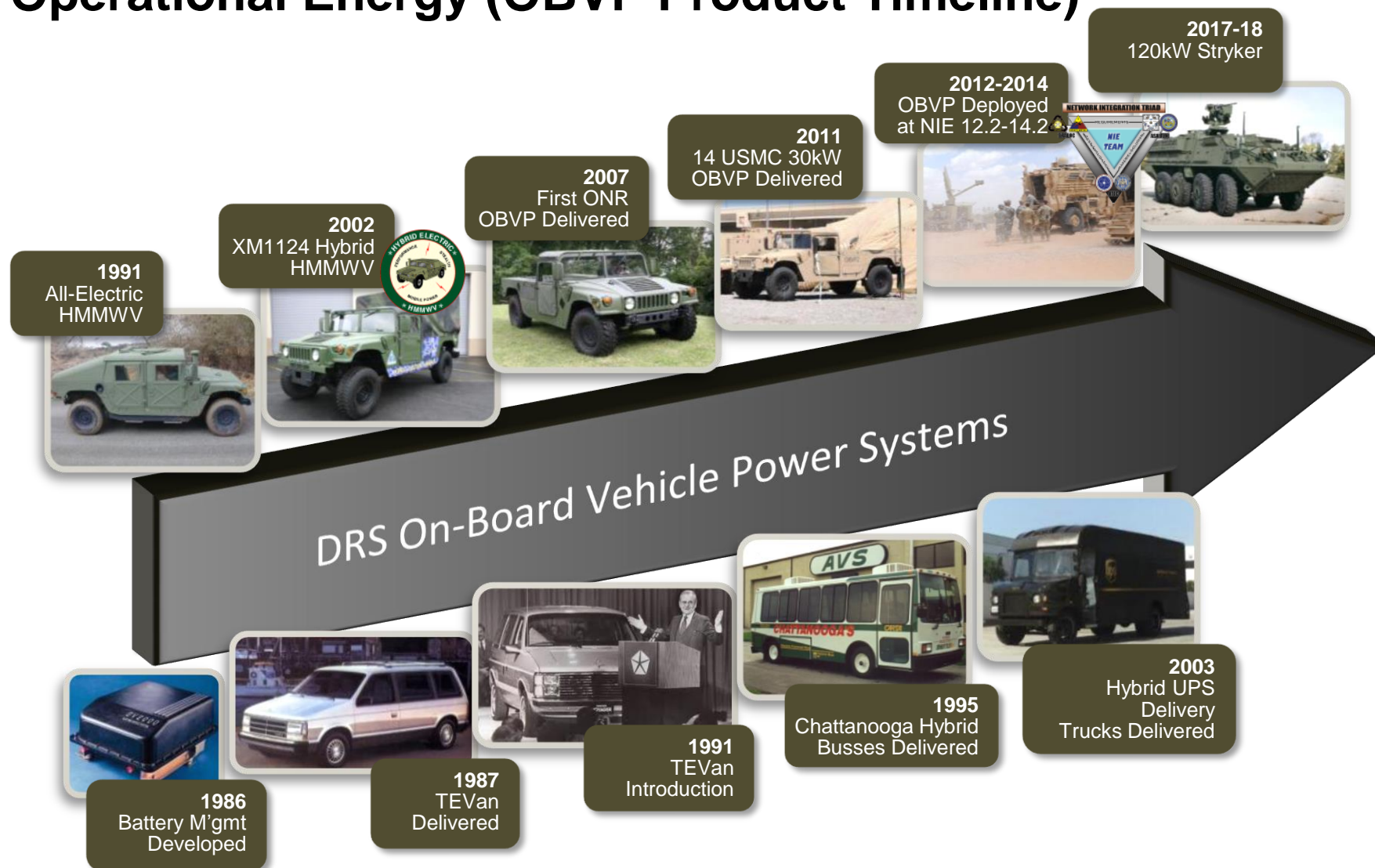
SUBJECT: Maneuver Center (MCoE) position on combat vehicle power and energy

1. MCoE position: Current levels of combat vehicle power and energy do not support the Brigade Combat Team (BCT) required capability to perform semi-independent operations nor to integrate combat vehicle technologies requiring additional power. To meet these capabilities requires a mid-term objective of a 50% increase in available power and a 100% increase in energy on each combat vehicle. The long term objective is an order of magnitude increase in power and orders of magnitude increase in energy.

Prepared by: COL Willie Nuckols

Approved by: MG Eric Wesley

Operational Energy (OBVP Product Timeline)



DRS has over 30 years in hybrid drive and vehicle power systems

OBVP Supported Platforms



OBVP Medium Truck

- ✓ Allison 3000 series Transmission
- ✓ 50 - 60 kW @ Engine Idle
- ✓ 120kW @ ~ 2000 RPM

FTMV



Stryker



MRAP



OBVP HMMWV, 1100 series

- ✓ 4L80E Transmission / OBVP
- ✓ 10 kW @ Engine Idle
- ✓ 30kW @ ~ 2000 RPM



HMMWV



OBVP Heavy Truck (Future)

- ✓ Allison 4500/4700/4800 Transmission
- ✓ 50 - 60 kW @ Engine Idle
- ✓ 120kW @ ~ 2000 RPM

SMDC HEL MD



THAAD Launcher

OBVP Enables Modernization Options



DRS OBVP Provides

- ✓ 50 - 60 kW @ Engine Idle or On The Move
- ✓ 120kW @ ~ 2000 RPM
- ✓ On-Board & Export Power, AC/DC
- ✓ Shore power capability during engine-off operations

Enabling Power for Every Mission

- ✓ Network, C4ISR, Radars, Sensor, Shooter, Counter IED, Survivability
- ✓ C-UAS / C-RAM / HE Laser / HP Microwave
- ✓ Exportable Power (TACs, TOCs, COPs, Launchers, Fire Control Stations, Ground Control Stations, Aviation Support Equipment, Field Hospitals...)

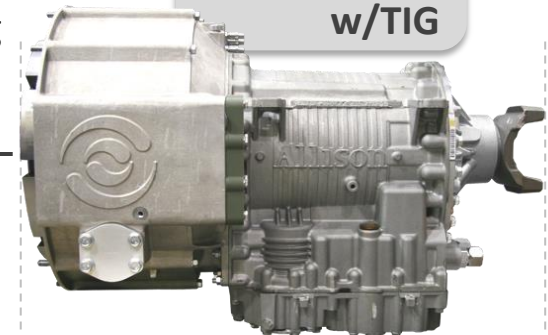
Enabling multiple Vehicle Modernization platforms

- ✓ Maintains existing vehicle's drive line configuration
- ✓ One for One vehicle transmission swap

Reducing Logistics Footprint

- ✓ Increased Power Output with Reduced Convoy Footprint
- ✓ Opens pintles for towing Water, Food, Ammo, Fuel – option to drop trailers from load plan for expeditionary operations
- ✓ Supplying Power In austere environments without burden of towed generators
- ✓ TARDEC V2G Study = 23% fuel savings over TQGs (Jul 2016)

**3200MSG
Transmission
w/TIG**



**3200SP
Standard
Transmission**

← 32.36 in (822.0 mm) →

OBVP Technology Employed at US Army NIEs

MiCP w/ OBVP		MCOTM w/ OBVP	
Description	Qty	Description	Qty
Miles:	135139	Miles:	352
OBVP run hours:	3422.1	OBVP run hours:	1256.8
as of 30 July 2014			
Total OBVP Hours:	4678.9	(constant run intervals)	
Weeks of operation:	116.97	(divide by 40 hrs)	
Days of operation:	194.95	(divide by 24 hrs)	
Major OBVP issues:	0	(zero failures)	
Major Engine issue:	0	(zero failures)	
Engine oil change	1		
Oil lubricity change	0.50%	(Per AOAP)	

The TIG system has been operated at multiple US Army NIE events and wet stacking was a question on the mind of the reviewers.

As evident above, TIG equipped vehicles have operated over several thousand hours and exhibited no wet stacking issues.

OBVP controls are CAN enabled and communicate with the vehicle engine to control engine speed based on load demand; mitigating any wet stacking issues.





Questions ?

INTERESTED IN ATTENDING?

Future weapons, including directed energy weapons have been in the Research & Development phase for the past several years. As the US armed forces, continue to develop and innovate in order to achieve battlefield overmatch and superiority, the Directed Energy weapon systems are making their way from the R&D phase to DoD and Military programs as the next step before acquisition and force integration.

Over the three-day summit we will examine the latest DE advancements, initiatives and plans regarding technology, acquisition and service roadmaps. This event will bring together thought leaders, acquisition executives, industry solution providers, and academia in order to tackle some of the challenges that face this community in the near, mid, and far term fight. We will look to gain insight and lessons learned from warfighter perspectives on the operational challenges and requirements of DES that will influence the capabilities of this game-changing technology.

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