Directed Energy Professional Society (DEPS)
Annual Directed Energy Science and Technology Symposium
22-26 March 2021 – Virtual Symposium

(U) Updates on JIFCO's DE IFC Weapon Development Efforts in 2021

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Purpose

- **Highlight Colonel Leimbach' s Plenary Talk**
  - **DE IFCs are applicable across the range of military operations**
  - **DE IFCs can mitigate JROC-approved "Joint Non-Lethal Effects (JNLE)" capability gaps as codified in the two JNLE Initial Capability Documents (ICDs) – counter-personnel & counter-materiel**
    - **Enable: (1) longer range IFCs; (2) greater volume of fire; (3) greater precision of (scalable) IFC effects; and (4) longer duration of effects**
- **Provide updates on key JIFCO DE-IFC Technology Development Efforts**
  - **Show proposed "Near/Mid/Far" predictions of our next DE-IFC technology development paths w/schedules**
- **Introduce this DEPS DE-IFC Conference**
  - **DE IFC example technologies include: dazzling lasers & focused acoustics; radio frequency – high power microwave vehicle and vessel stoppers; laser induced plasma weapons, and Active Denial Technologies.**
  - **Highlight several key events/milestones that are important to the DE-IFC and greater DEW community**
    - **"Fear-of-the-New" and "First-Use of DE-IFCs" Study to rid ourselves of the DEW "Death-Ray" myth**
    - **Highlight keep cooperative engagements between the JIFCO and other DoD/Government agencies (to include the DEW community) to consider next-generation S&T DEW development efforts for DE-IFCs & DEWs in general**
    - **Spur continued DE subsystem/component and peripheral system breakthroughs to drastically improve DEW size, weight, power consumption, thermal cooling, and cost (SWAP/C2) improvements**

Utility of Directed Energy Intermediate Force Capabilities Across Warfare Spectrum

"Gray Zone" competition dominates any conceptual Spectrum of Warfare and is ideally suited for Intermediate Force Capabilities

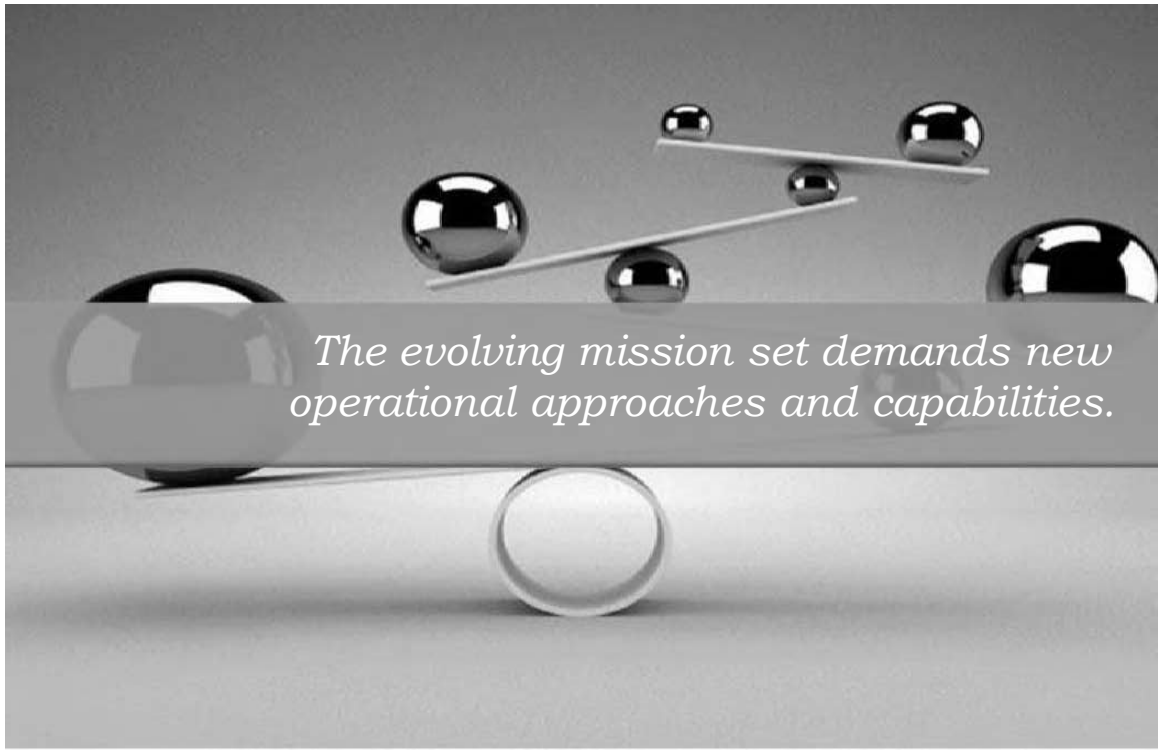
Phases of Warfare

Competition Continuum

IFCs are a ***strategic risk mitigation investment*** that provide warfighters tools to seize the initiative while competing below the level of armed conflict.

DE- IFCs can shift the competition balance in our favor

"Gray Zone" competition dominates the Spectrum of Warfare/ROMO and is ideally suited for DE - Intermediate Force Capabilities



Can a balanced/optimized "Use of Force" concept (with non-lethal/scalable weapon effects) influence these conditions?

- Either keep it balanced or tip and slightly disrupt this balance to our favor?
- Can we "engineer" mission outcome with these often covert/plausible deniable IFCs?

IFCs are a ***strategic risk mitigation investment*** that allow the warfighter to shift the balance in our favor while competing below the level of armed conflict.

Current vs. Advanced Technology IFC Initiatives/Concepts

Current Capabilities

Flashbang Stun Grenades

40mm Munitions
(Blunt Impact, Flashbang, RCAs)

Stingball Grenade

12 Gauge Munitions
(Blunt Impact, Flashbang, RCAs)

Spike Strips

Acoustic Hailers

Tethered TASER (Short Range)

Dazzling Lasers (Short Range)

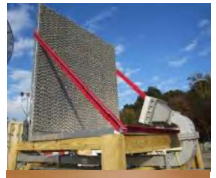
Human Effects Risk Characterization

Next Generation Capabilities

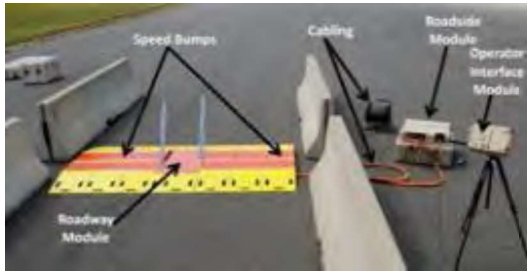
Escalation of Force CROWS Concept for IFC Kit
(Projected Demo - FY23)

Remotely Deployed Vehicle Stopping Nets

Non-Lethal Directed Energy Weapon - Size, Weight, Power consumption, thermal Cooling, and Cost reductions (SWAP/C²)



Pre-Emplaced Electrical Vehicle Stopper (Ongoing Pilot Program)



Tetherless Human Electro-Muscular Incapacitation (HEMI) Munitions

Dazzling Lasers (Long Range)

Occlusion Technology

Some Examples of DE IFC Technologies

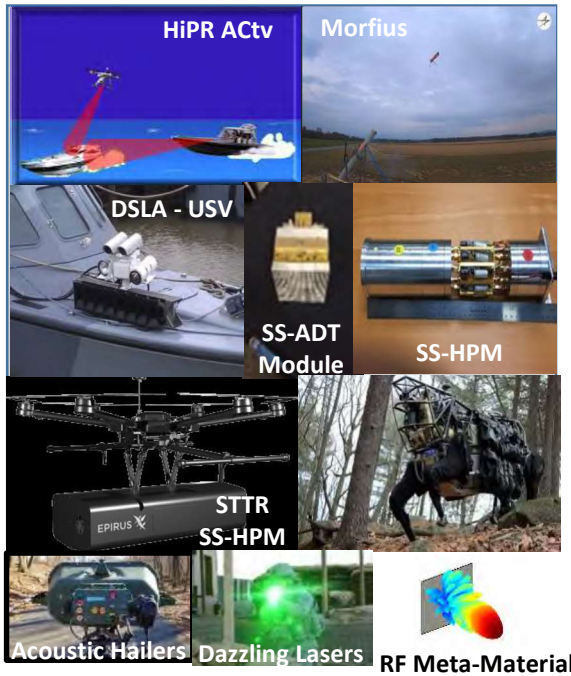
Millimeter Wave Active Denial System (Tube-Based)

Current Form Factor
(Two systems exist)

Millimeter Wave Active Denial System (Solid-State)

Future Form Factor
USA –Focused Assessment
(Projected 1st QTR 2021)

Long-Range IFC Payloads (DE & Non-DE Payloads)



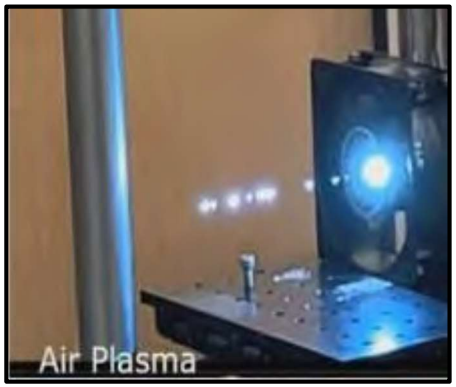
High Power Microwave Vessel Stopper

USCG Directed Energy Vessel Stopper
Afloat Military Utility Assessment

High Power Microwave Vehicle Stopper

Prototypes under development

Laser-Induced Plasma

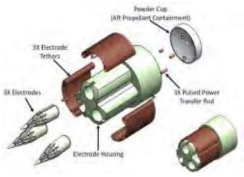


Audio / Physical / Thermal
Effects at Extended Range

USMC/JIFCO IFC Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs

Phase I

- **Feasibility** (Feasibility Study)
  - *Focused Enhanced Acoustic-driver Technologies (FEAT) – 123 dB acoustic drivers* (Source Selection) – Phase I (2021)
  - *Improved Laser Induced Plasma Effects Device - LIPE ultra-short pulse lasers – awarded Phase II – FY20 prototype*
  - *Optimized Short Pulse Source - Higher-Power Microwave Vehicle Stopper* – (STTR – Solid-State HPM) – Phase II awarding (FY21)
  - Focused Directed Energy Antenna Systems (FoDEAS) – compact/lightweight/high gain - wideband HPM Antenna – Phase II awarding (2022)
  - **FY21 US Army XtechSBIR -ASA(ALT) – Non-Lethal Driver Defense SBIR (Two Phase 1 SBIRs awards in Jan/Feb 2021)**
  - **FY21-22: DIRECT To Phase II Compact (5-20kW) Genset; IFC Payload; Broadband Compact HPM Source**



12 ga. HEMI Munition

Solid-State HPM STTR

FoDEAS – wideband HPM Antenna

Phase II

- **Demonstration** (Technology Development & Prototype Demonstration)
  - *HEMI Munition – 12 ga. – (In process) – FY22 prototype*

Light Weight High Power Density Generator – Candent + Heat Exchanger

Phase IIB

- **Prototype Testing & Evaluation, Technology Demo & Validation**
  - ***Recuperated 480lb – 300kW High Power Density, Generator*** *for DEW systems* - Candent (delivered & tested – Aug 2021) – includes Mezzo International Inc. micro-tube heat exchanger design - previous SBIR

Laser Induced Plasma

FEAT – Acoustic Drivers

Phase III

- **Commercialization** (Transition to Acquisition Program)
  - Generators support JIFCO NL DEW prototype & DEW community

DE-IFC Technology Development "Path Forward" - What is the "Now" and What is the "Future" (Near, Mid, Far)

1. ADT Solid-State Active Denial Technology – 94/95 GHz GaN MMICs

Near:

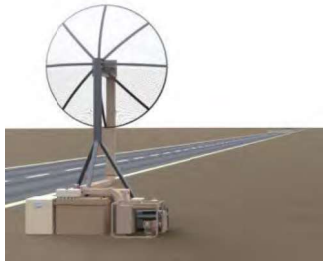
- 1 Watt/mm; 28% Pae - GaN MMICs (2018)
- 2 Watt/mm; 30% Pae -GaN MMICs (2020)
- 5-10 Watt/mm; ~30% Pae - MMICs – DARPA DREaM - (2022)

Mid:

- 10 Watt/mm; 45-65% Pae – Next-Gen MMICs/Architectures – New materials (e.g. diamond and HV dielectric constant materials) - (2030 - 2040)

Far:

- 100 -1000+ Watt/mm; 66% Pae (2040)
- Reduced SWAP/C^2 in 2060



Power Amplifying Radiator (PAR)

2. Radio Frequency – High Power Microwave (RF-HPM) Vehicle/Vessel (V/V) Stoppers, & other Counter-Electronic Weapon Systems

Near:

- 5-40MW – L and S-band Magnetrons V/V Stoppers (2020-2025)

Mid:

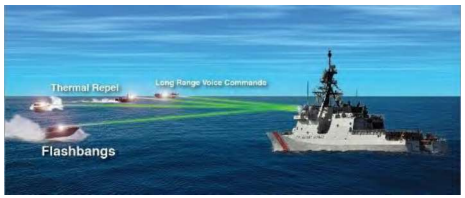
- Short Pulse Source HPM technologies – In-band and non-in-band 10's to 100's of Megawatt/Terawatt-class Magnetrons with Diffraction Output MDOs, Super-Reltrons, Non-Linear Transmission Lines (NLTLs), and Solid-State HPM Sources) (2025-2030)
- 10's to 100's of Megawatt-class+ High Power Solid-State HPM Sources (2030-2040) – DARPA DReAM+ efforts

Far:

– Reduced HPM weapons system SWAP/C^2 in 2060

SWAP/C^2 enabled UxS Integration

Non-Lethal Directed Energy Weapons (NL DEW) - What is the Now and What is the Future (Near, Mid, Far)



3. Long Range Sound & Light Technologies

Near:

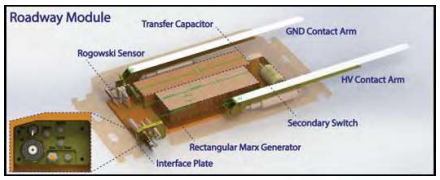
- Green Dazzling Lasers and Focused Acoustics (9W DPSS laser & 109 dB acoustics drivers with adaptive beamforming) (2020)
- Laser Induced Plasma Technologies (flashbang, thermal, and intelligible voice commands) – (2020)

Mid:

- 123 dB+ compression driver & 30W DPSS dazzling laser (2020-2025)
- 5-6 km LIPE capability with adaptive optics (2025-2030)
- 20+ km LIPE capability to unbalance the Gray War Competition (DARPA) (2030-2040)

Far:

- Reduced Sound & Light SWAP/C^2 in 2060 – for long-range hail/warn & suppress/distract/repel



4. Conducted Energy Weapons (CEWs)

Near:

- Pre-Emplaced Electrical Vehicle Stopper (PEVS) – (2020)
- 5-100m – 30+ sec 12 gauge/40mm Untethered HEMI Munition (2020-2023)

Mid:

- Contactless PEVS – Near-Field RF-HPM Antenna- based PEVS technologies (2021-2030)
- Laser Induced Plasma Channels (LIPC) (2025-2035)
  - CP HEMI
  - CM Direct Inject
  - CUAS/UxS
  - RF/HPM – mm-Waves
- Autonomous CEWs for IFCs

Far:

- Reduced SWAP/C^2 in 2060
- Long-range – long duration UxS-delivered CEW intermediate force capabilities

Non-Lethal Directed Energy Weapons (NL DEW) - What is the Now and What is the Future (Near, Mid, Far) Summary

1. Intermediate Force Capabilities is the "now and the future"
2. Grey War will be with us for some time – It is the Now and the Future
   - High Percentage of "Gray" Conflict vs High Intensity Conflict
   - Enduring IFC Vignettes – Now and in the Future

Star Trek PHASER
–PHASER on Stun
– PHASER on kill

3. Current Warfighter Needs vs Future Needs
   - Joint Non-Lethal Effects ICDs (now and in the future) – Enduring IFC Missions/Cap-Gaps
4. IFC/Non-Lethal Directed Energy Weapons (NL DEW) - the Now and the Future (Near, Mid, Far)
   1. Active Denial Technologies (ADT)
   2. RF-HPM Vehicle/Vessel Stoppers
   3. Long Range Sound & Light Technologies
      - Long Range Hail and Warn & Scalable Laser Induced Plasma Effects
   4. Conducted Energy Weapons (enabled by DEWs)
   5. **2060 IFC Weapons of Star Trek**
      - **Single reduced SWAP/C^2 Weapon Technology**
        - **Detect, ID, Track, C4ISR, Comm, IFC/NL, Lethal**

Star Trek
Transporter

Star Trek
Tractor Beam

Highlight Several Key Events/Milestones that are important to DE-IFCs and to the greater DEW community

1. Colonel Leimbach's DE-IFC plenary talk:
   - **DE-IFCs are applicable across the range of military operations**
   - How the DEW community might rid ourselves of the: **"Fear-of-the-New" and "First-Use of DE-IFCs" Study to rid ourselves of the DEW "Death-Ray" myth – completed in FY21-22**
2. JIFCO is teaming with:
   - ONR Code 35 (Dr. Ryan Hoffman) to fund DE BA-1 – "basic science" Initiatives to foster next-gen breakthroughs – FY22 and out
   - DARPA MTO to mature solid-state high power microwave sources (FY21-22)
   - OSD (R&E) to develop and run DE-IFC war games (FY21)
   - DARPA & the DE-JTO to mature short pulse and ultra-short pulse laser technologies to develop long range laser induced plasma weapons (FY22-25)
   - USCG to operationally assess (at-sea) a RF-HPM Vessel Stopper (FY25)
   - Operational assess a RF-HPM Vehicle Stopper (FY22-23)
   - Transition a Pre-Emplaced Electrical Vehicle Stopper system design to an end-user (FY21)
   - Team with Service ManTECH organizations to spur SWAP/C^2 breakthroughs
   - Investigate other DEW & DE technologies for DE-IFC missions (e.g., develop new DE-IFC Vignettes)