



# Department of Defense Non-Lethal Weapons Program

## Next-Generation Non-Lethal Directed Energy Weapons for the Department of Defense and Homeland Security

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to

National Defense Industrial Association (NDIA)  
2015 Armament Systems Forum  
Unconventional & Emerging Armaments – Non-Lethal Technology Conference  
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Baltimore Marriott Inner Harbor at Camden Yard

<http://jnlwp.defense.gov>





# Purpose

- **Set the context of what the JNLWD does and provide a non-lethal directed energy weapon (DEW) technology overview of our future DEW technology investment areas and how they assist in (scalable) Escalation-of-Force (EoF) missions**
  - JNLWD Origins & Founding by congress
  - Organizational Structure defines formal reporting chain
    - Voting and Non-Voting members of the JNLWP
  - Non-Lethal Weapons in use today (mostly short range & non-DE)
- **Highlight primary demand signals:**
  - JNLWP budget (RDT&E and S&T) - nearly 100% dedicated to Joint Non-Lethal Effects ICD - identified capability-gaps (counter-material and counter-personnel)
  - Notional next-generation NL DEWs and how they assist in EoF missions
- **Discuss the DoD's Human Effects (HE) Characterization process (to include NL DEW HE characterization)**
- **Show near-term NL DEWs currently in develop (with key peripheral DEW technologies) relevant to the Department of Defense and Homeland Security missions – “smaller, lighter, and lower cost”**



# DoD Non-Lethal Weapons Program



## DoD NLW Program Established 1996

- Operation United Shield (Somalia): General Anthony C. Zinni pioneered use of NLW
- FY96 National Defense Authorization Act directed DoD to centralize responsibility for NLW



## Program Highlights

- CMC designated Executive Agent
- Joint research and development funding
- Services responsible for NLW procurement



General Joseph F. Dunford, Jr.  
Commandant of the U.S. Marine Corps



## Vision

*“A fully integrated non-lethal competency within each Service, to complement lethal effects, enhance the Joint Force's adaptability, and support strategic objectives that include minimizing civilian casualties”*

## Non-Lethal Weapons

Applicability across “New Normal” scenarios

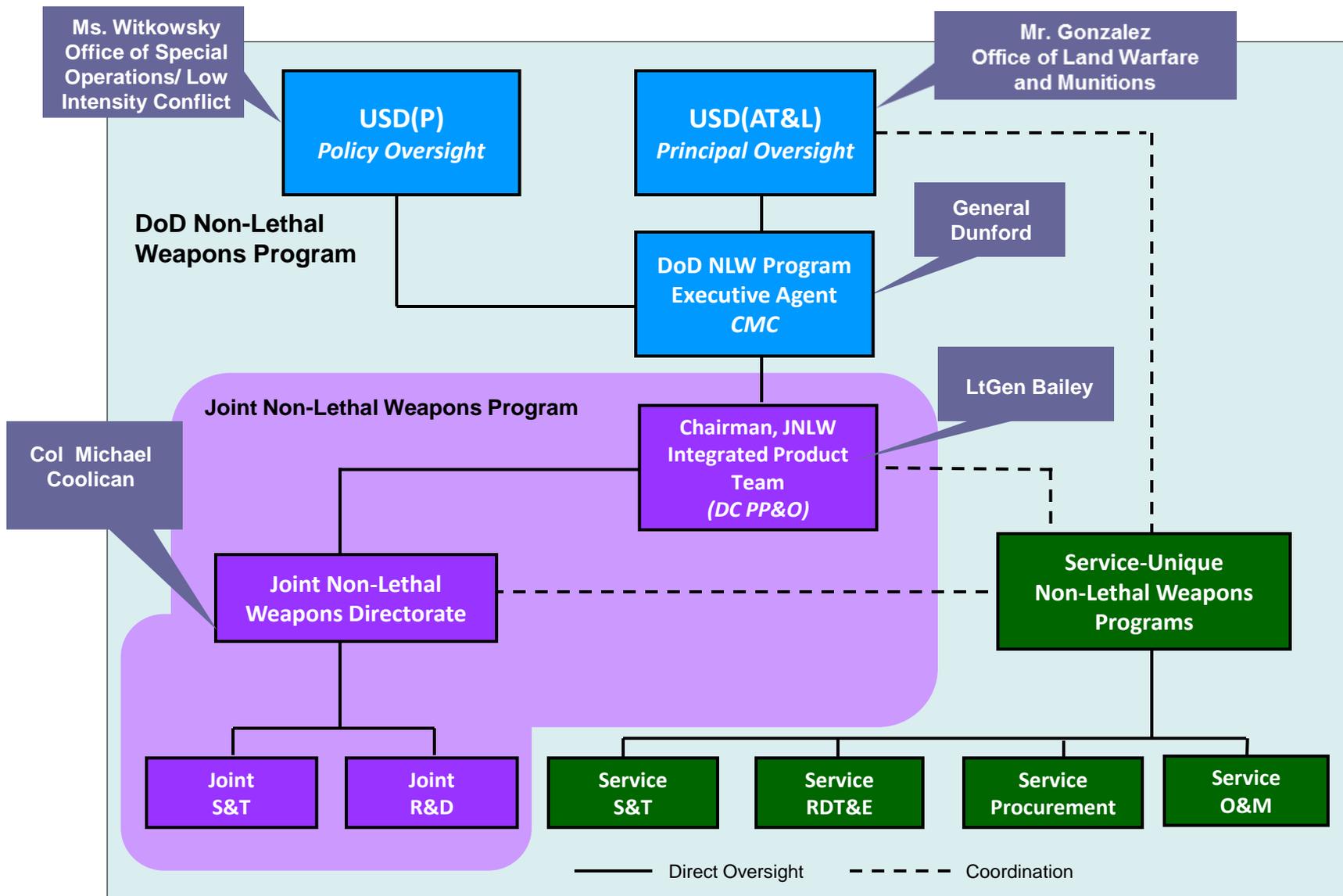
- Humanitarian Assistance/Disaster Relief
- FOB/Area Security/Security Cooperation
- Stability Operations



**Non-Lethal capabilities assist operating forces in minimizing civilian casualties and collateral damage**



# DoD NLW Program Organization





# JNLWP Management Structure

**Executive Agent  
Commandant, USMC**



Joint Integrated Product Team



## Joint Integrated Product Team (JIPT)

- Approves JNLWP budget
- Approves resolution of program issues
- Reviews Joint & Service-unique programs



Joint Coordination & Integration Group



## Joint Coordination & Integration Group (JCIG)

- Recommends program priorities for development and funding
- Recommends lead-Service designations

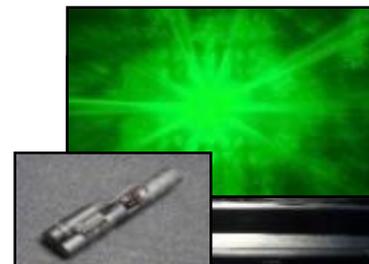
Non-Voting Members - OSD, DOS, DOJ, DOE, DHS, NGB, Combatant Commanders and Joint Staff have representation on the IPT and JCIG



# Non-Lethal Weapons in Use Today



Washable Paint      FN303      Training  
Permanent Paint



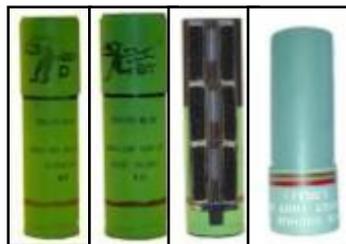
Optical Distractors



X-26 Taser



Modular Crowd Control Munitions



66mm Vehicle Launched NL Grenades



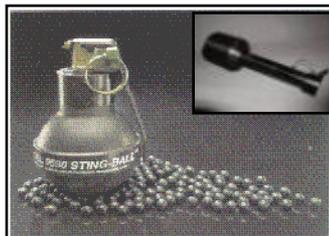
Flash Bang Grenades



Portable Vehicle Arresting Barrier



Vehicle Lightweight Arresting Device M2 Net



Stingball Grenades & Launch Cups



Vehicle Non-Lethal/Tube Launched Munition System (VENOM™)



Acoustic Hailing Devices

Green font – Rapid Acquisition Initiatives

Distribution A: Approved for public release; distribution unlimited

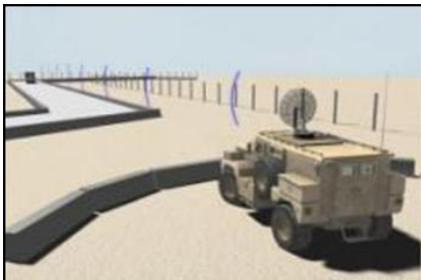


# JNLWP Non-Lethal Directed Energy Investment - Why



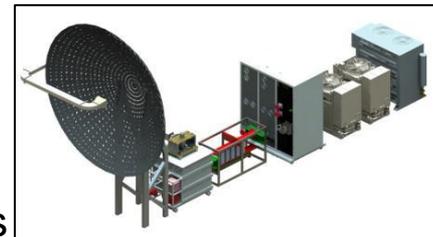
## Strengths

- Range
- Speed of delivery
- Volume of fire
- Duration of effect
- Precision engagement
- Controlled effects (scalable effects)
- Electronic magazine
- Logistics



## Weaknesses

- Size and weight
- Source technology
- Power requirements
- Ruggedization
- High cost
- Specialized training requirements



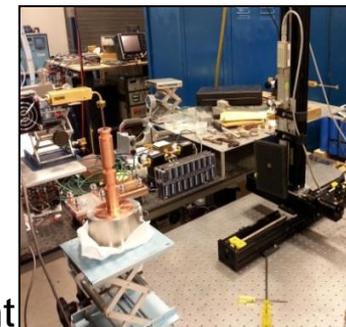
## Opportunity

- World's Directed Energy lead
- Game changer
- Addresses multiple missions/applications



## Programmatic Threats

- Misperceptions
- Initial prototype costs
- Limited leverage
- New battlefield effects
- Bomb damage assessment
- Legal, treaty, and policy
- Kinetic vs non-kinetic weapon comparisons



**Non-Lethal capabilities assist operating forces in minimizing civilian casualties and collateral damage**



# Joint Non-Lethal Effects (JNLE) Tasks

## Top Ten Tasks

- 1) *Stop Vehicle (small, confined, single)*
- 2) *Stop Vehicle (medium, confined, single)*
- 3) *Stop Vehicle (large, confined, single)*
- 4) *Stop Vessel (small, confined, single, [friendly anchored])*
- 5) *Suppress Individuals (confined, single/few)*
- 6) *Suppress Individuals (open, many)*
- 7) *Stop Vessel (small, open, single, [friendly underway])*
- 8) *Deny Access into/out of an area to individuals (confined, single/few/ many)*
- 9) *Deny Access into/out of an area to individuals (open, single/few/ many)*
- 10) *Move Individuals through an area (open, many)*

## JCIDS – Joint Non-Lethal Effects ICDs

- *Joint Capabilities Document signed February 2008*
- *CP & CM Initial Capability Documents signed April 2009*
- *Joint Non-Lethal Effects Tasks re-validated in 2013*

## Counter-Personnel Tasks

- *Deny*
- *Move*
- *Disable*
- *Suppress*

## Counter-Materiel Tasks

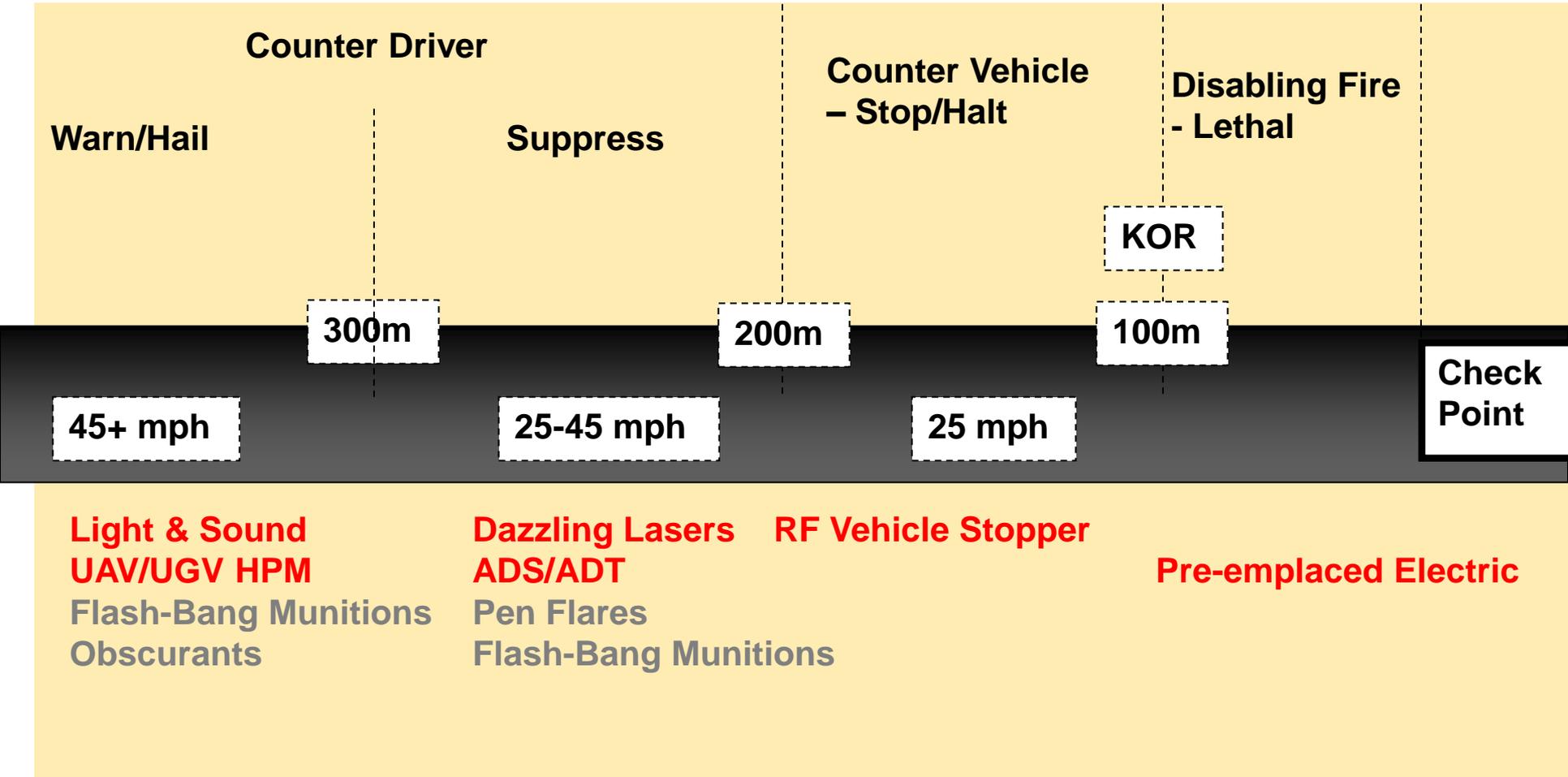
- *Stop Vehicle*
- *Disable Vehicle*
- *Stop Vessel*
- *Disable Vessel*
- *Stop Aircraft on Ground*
- *Disable Aircraft on Ground*
- *Divert Aircraft in Air*
- *Deny Access to Facility*

## Capabilities Based Assessment Membership

J2/J3/J8	PACOM	USA	JNLWD
JFCOM	CENTCOM	USCG	OSD AT&L
EUCOM	STRATCOM	USMC	HECOE
	NORTHCOM	USN USAF	



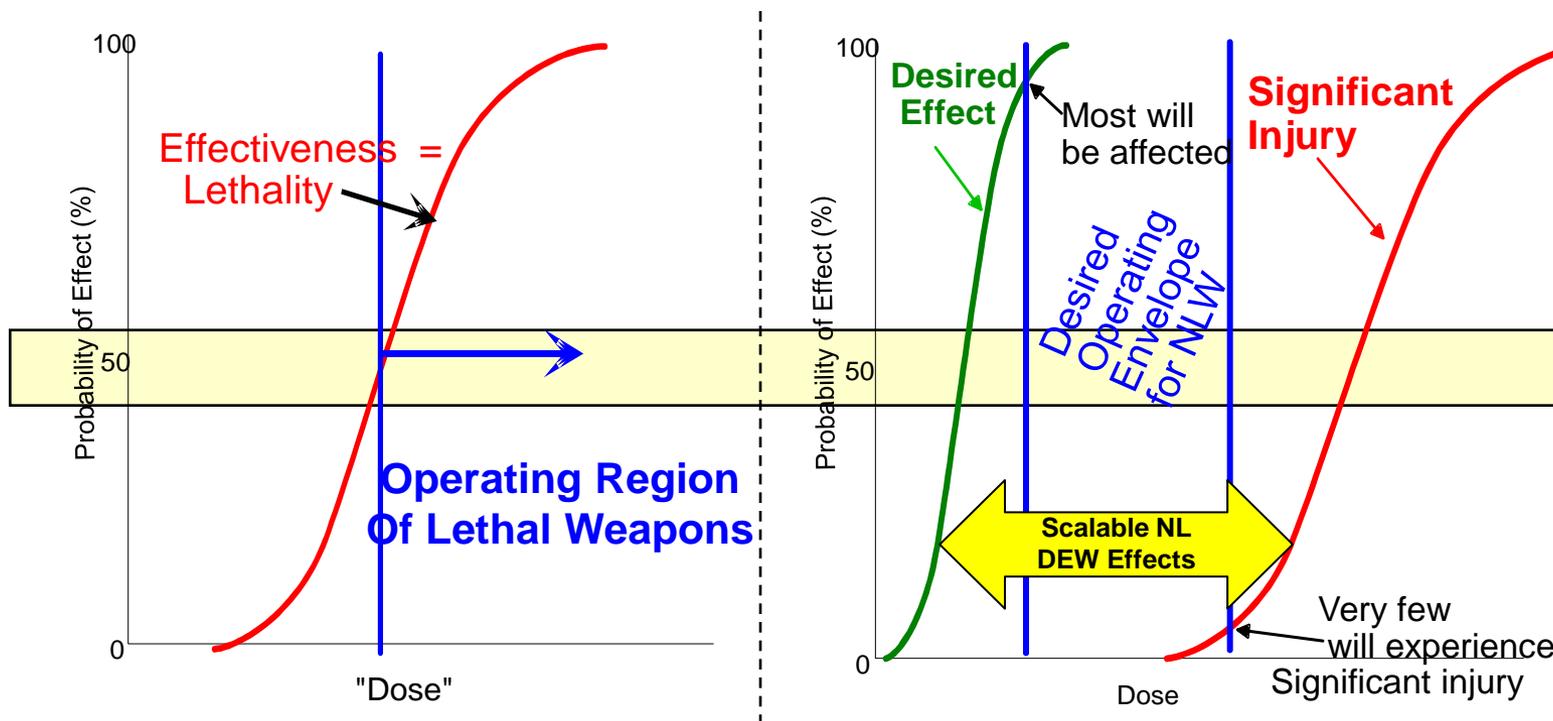
# Notional Escalation of Force & how NL DEWs help - a Vehicle Stopping layered defense mission



**@ 45 mph close from 300 m to 100 m in ~10 seconds**



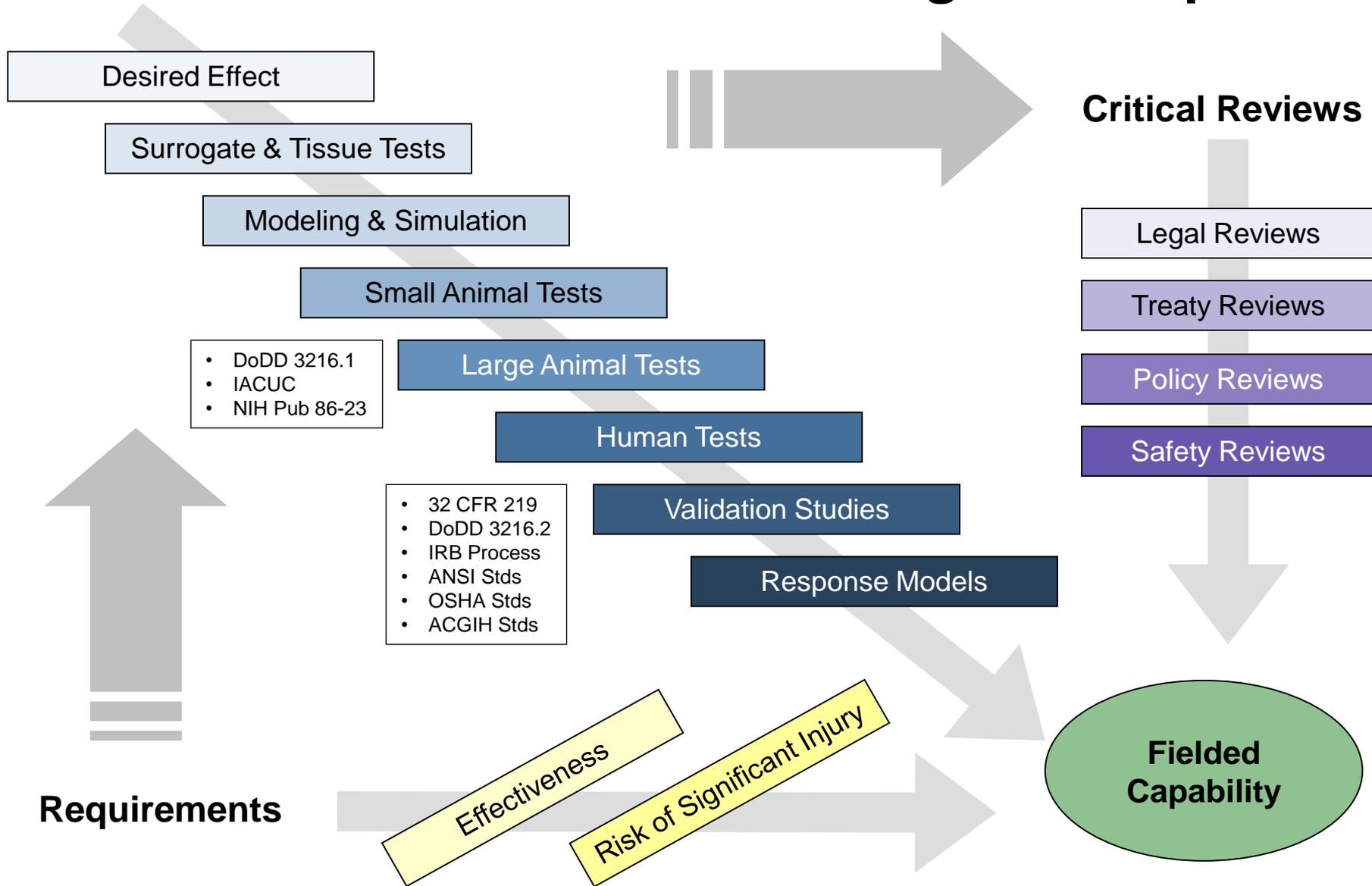
# NLW Human Effects Characterization



- Generally, the goal of lethal weapons has been to maximize a single effect: lethality, while meeting the constraints of Law of Armed Conflict, logistics, cost, etc
- For NLW, two competing objectives exist: cause a desired effect, while minimizing permanent injuries or fatalities
- Understanding human effects is critical for legal/treaty reviews, policy acceptability, and warfighter awareness
- Non-Lethal Directed Energy Weapons can provide some degree of scalability of the effect



# NLW Human Effects Characterization follows the Effects Based Design Concept





# JNLWP Human Effects Processes



—————> Direction/coordination

.....> Reports

## JNLWD – Human Effects Branch

- Provide HE Strategy
- Resource HE Research
- Coordinate HE Reviews

### Human Effects Review Board (HERB)

- Joint Service Board of Medical & Safety Officers
- Legal Treaty, & Policy SME Representatives
- HE Safety, Training, Experimentation Guidance

### Human Effects Advisory Board (HEAP)

- Blue Ribbon Non-government Board of Medical/Bio-effects SMEs

### Technology Effectiveness Advisory Panel (TEAP)

- Government & Non-government Blue Ribbon Board of NLW Effectiveness SMEs

## Human Effects Center of Excellence (HECOE)

- Portfolio (research) Managers
  - Directed Energy, Blunt Impact, Acoustics, HEMI, etc.
- HE Knowledge-base, Consultative Expertise
- HE – Modeling Analysis Program (HE-MAP)
- Human Effects Risk Assessments

Treaty, Legal, Policy Reviews

Program Manager

Milestone Decision Authority

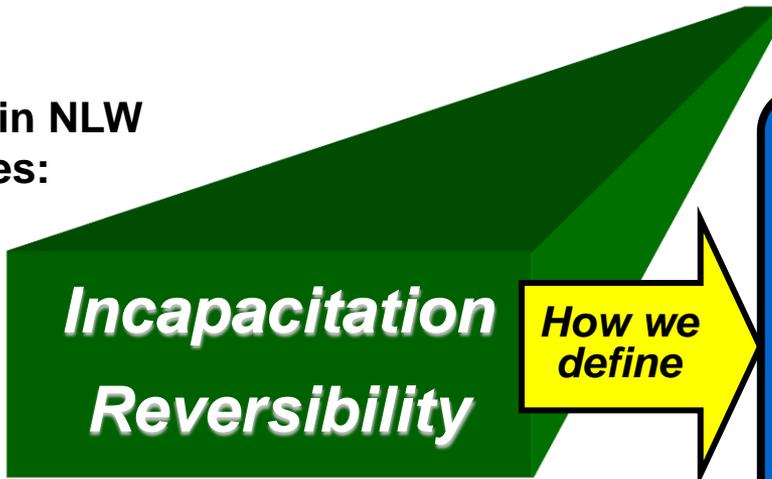
Fielded Capability





# Risk of Significant Injury (RSI) Approach

Two main NLW attributes:



DODI 3200.19, "Non-Lethal Weapons (NLW) Human Effects Characterization" dtd 17 May 2012 codifies RSI

**Risk of Significant Injury**

- Based on Established DOD Health Care Capabilities (HCC) Continuum
- Ties RSI to JP4-02 HCC standards using an intuitive continuum
  - Limited First Responder Capability  
"Expected"
  - RSI = Other First Responder Capability  
"Injury Risk"
- Focuses on Risk "Management" vice Risk "Avoidance"

- **DOD-Wide Acceptance On:**
  - ✓ Definition of Permanent Injury
  - ✓ Definition of Reversibility
  - ✓ Definition of Risk of Significant Injury (RSI)
- **Most NL Stimuli has been characterized by the JNLWP to include NL DEW waveforms**





# Current FY15-16 Non-Lethal Weapon Demonstrators



## Distributed Sound and Light Array (DSLA)

- Phased acoustical array and optical interrupting device
- Provides hailing and warning and optical suppression capabilities
- Combined effects of two integrated sensory stimulators for unambiguous long range (600m+) hail and warn

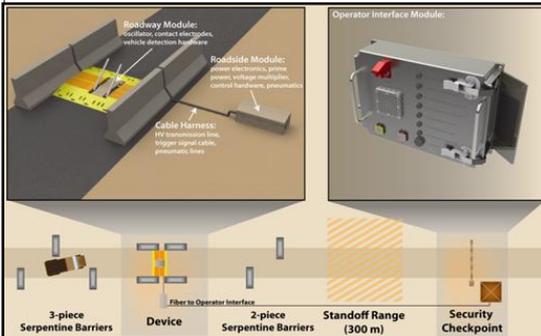


## Active Denial System (ADS)

- Provides ability to repel/suppress personnel and vehicle/vessel operators up to 1,000m
- Uses “millimeter waves” not “microwaves”
- Legal, treaty and arms control compliant
- ADS was recently integrated in I MEF Exercise Valiant Mark (December 2014). Marines from 1/5, 1<sup>st</sup> Marine Division were engaged with ADS.



ADS 2: 1,000m range; 1.5m spot size



## Pre-Emplaced Electrical Vehicle Stopper (PEVS)

- Pre-emplaced, electric, direct injection “speed-bump” system
  - Employs high voltage pulse to disrupt vehicle’s ECU
- Selectively stops single or multiple threat vehicles
- Non-lethally stop vehicles at significant keep-out ranges
- Low cost per shot and has a long lifetime (> 3000 shots)
- Reduces risk to personnel from vehicle-borne IEDs



**Non-Lethal DEW capabilities assist operating forces in minimizing civilian casualties and collateral damage**



# Future: Non-Lethal Counter-Personnel Directed Energy Weapons



## Active Denial System – Legacy Systems

- Advanced Concept Technology Demonstrator
- Proven Effects – 95 GHz effects
- Effective at long-ranges

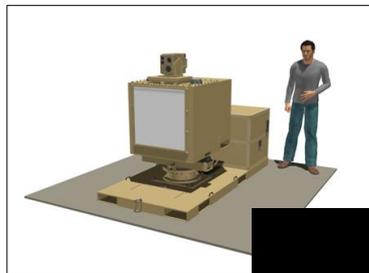
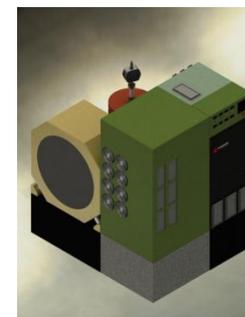
## Compact ADT

- Demonstrate the same effectiveness in an operationally suitable configuration
- Develop a compact, lightweight second harmonic Gyrotron with a room temperature electroper magnet

40-kW CW Electroper magnet Gyrotron



90-kW CW Demonstrator



## Solid State (SS) ADT

- Develop a compact, self-contained, NL SS-ADT demonstrator
- Significant reduction in size and weight
- Cost sharing effort between Army Research & Development Center and JNLWP



## Sound & Light Portfolio

- Distributed Sound and Light Array – technology development/improvement efforts

## NL Counter-Personnel Lasers

- Technical lead on an USMC-funded Phase II SBIR to demonstrate long range (>100m) high repetition rate flash-bang effects, thermal discomfort, and long range intelligible acoustic hailing capabilities via laser induced plasmas

## Other Key Peripheral NL DEW Sub-Systems

- USMC SBIRs: Advanced Thermal Management; Compact Prime Power; Compact RF Antennas



**DoD Non-Lethal Directed Energy Investment**



# Future: Non-Lethal Counter-Materiel Directed Energy Weapons



- High Power Microwave (HPM) Portfolio & Counter-Electronics Systems
- Directed Energy: Radio Frequency (HPM) Vehicle and Vessel Stopper
  - Provides several advantages over existing non-lethal capabilities with extended range, ability to hold vehicles immobilized until released, and safe and reversible effects
  - New design will provide multi-mission capabilities and various CONEMPS



Laboratory Breadboard

FY08–FY11

SIZE: 1360 ft<sup>3</sup>

WEIGHT: 9,500 lbs



Long Range Demonstrator

FY12

SIZE: 895 ft<sup>3</sup>

WEIGHT: 9,500 lbs



Compact Modulator

FY 14

SIZE: 450 ft<sup>3</sup>

WEIGHT 4,500 lbs



Force Protection

FY17/18

SIZE: 200 ft<sup>3</sup>

WEIGHT: 4,000 lbs

**RF Vehicle-Stoppers**



Force Application

FY17/18

SIZE: 50 ft<sup>3</sup>

WEIGHT: 2,000 lbs

**RF Vessel Stoppers**



Narrowband HPM



Wide-band HPM

## Other Peripheral NL DEW Systems

- USMC SBIRs: Advanced Thermal Management; Compact Prime Power; Compact RF Antennas



**DoD Non-Lethal Directed Energy Investment**

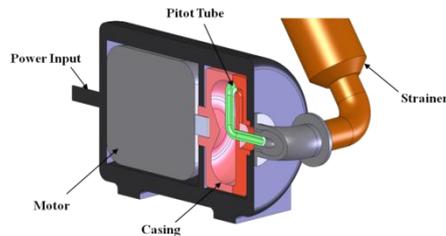
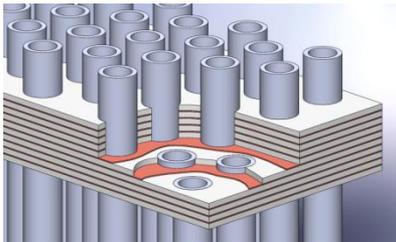


# Key NL DEW Peripheral Technologies

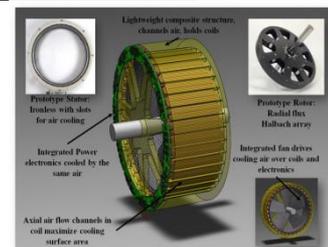
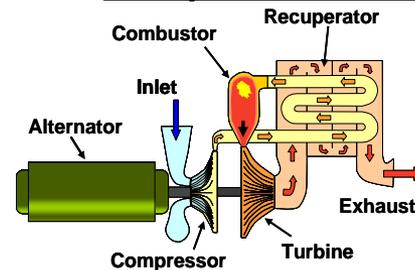


- All currently being developed under USMC SBIRs (Phase II) as led by the JNLWD and MARCORSYSCOM

## Advanced Compact Thermal Management Systems (TMS)



## Compact NL DEW Prime Power



Contract M67854-11-C-6508 with Mezzo Technologies

- Micro-tube based thermal cooling system that employs a phase change material that **reduces the current thermal management system by ~ 65% in both size and weight over conventional thermal coolers**
- Phase II prototype system being built to support the JNLWP's 40 kW Compact Active Denial Technology prototype which is being built by UC Davis.

Contract M67854-11-C-6510 with Thermal Form & Function

- Developed pitot pump sizing tool/model & completed computational fluid dynamic analysis on this compact low power Pitot Pump design. This model can now be employed to correctly size/design low power Pitot Pumps for many existing Directed Energy Weapons **reducing their current TMSs by ~ 65% in weight and size.**
- Developed Pumped Liquid Multiphase Cooling (PLMC) & Vapor Compression Refrigeration system for sub ambient cooling on the 90 KW Compact ADT system and the RFVS prototype.

Contract M67854-14-C-6507 Candent Technologies Inc.

- Small gas turbine** powered, advanced power generation system capable of producing **250 kW.**
- Develop an advanced power generation system capable of producing 250 kW of continuous electrical power at an altitude of greater than 10,000 ft and an ambient temperature of 80oF at that altitude. The complete system **weight** goal is **< 500 pounds,** with an overall **volume** goal of **≤ 27 cubic feet,** having a fuel consumption of 4.6 kW-hr/kg at 75% power, and 4.7 kW-hr/kg at 25% power.

Contract M67854-14-C-6510

Toyon Inc.

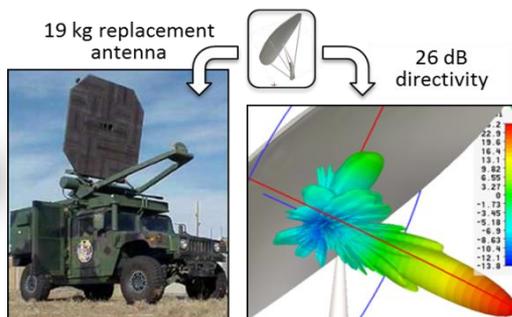
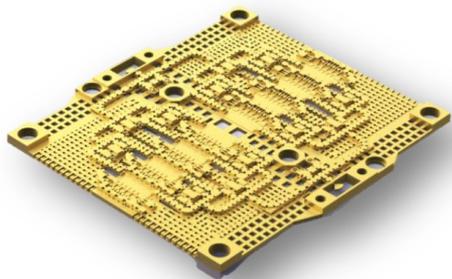
- A Lightweight 150-250 Watt Efficient Generator technology comprised of a heavy fuel, turbocharged, **rotary engine** employing a direct injection stratified charge combustion process in conjunction with a forced air cooled high power density (HPD) motor/generator with a total weight less than 500 lbs.



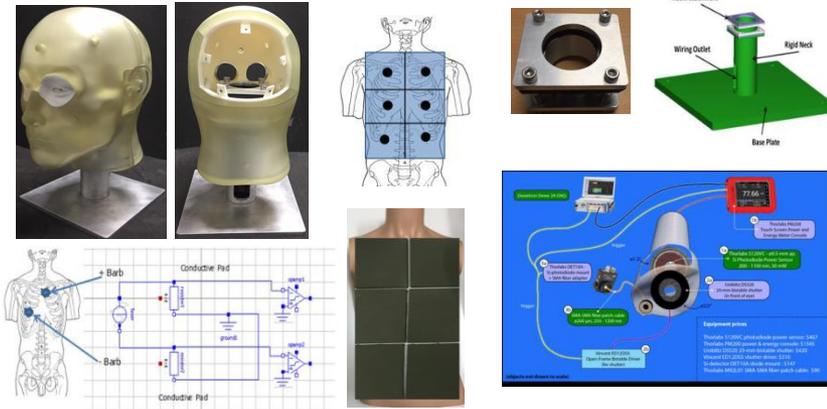
# Key NL DEW Peripheral Technologies

- All currently being developed under USMC SBIRs (Phase II) as led by the JNLWD and MARCORSSYSCOM

## Compact RF Antennas



## Human Surrogate Test Target



## Contract M67854-14-C-6501 with CFD Research Corp.

- The overall objective of this project (Phase I, II, and III) is to develop, fabricate and test a novel, modular **human test surrogate target**, consisting of a human head/neck/torso, that can be used to evaluate non-lethal weapons and validate software input for the JNLWP HEMAP software. The CFDRRC and JHU/APL team is applying its extensive knowledge of modular phantom development to design an integrated test surrogate capable of measuring blast overpressure, kinetic/blunt impact, **directed energy** (sound, light/laser, electromagnetic fields, radio frequencies, thermal energy), and chemical irritants. CFDRRC will create a virtual surrogate as well for use in modeling software. This will allow for precise validation and agreement between the physical and virtual models.

## Contract M67854-11-C-6508 with Nuvotronics Inc.

- Use of novel micro-coax transmission lines and integrated antenna feed to improve efficiency of front-end antenna for the US Army's (Raytheon-developed) GaN –based 95 GHz **Solid State Active Denial Technology (SS ADT) Skid-Plate demonstrator**.
- Improves current Raytheon amplifier modules using Poly-Strata coax
- Reduces packaging cost by 5X** by using an integrated 94 GHz coax circuit, Improves reproducibility of RF modules, and enables electronic vertical direction scanning .

## Contract M67854-11-C-6508 with RadiaBeam Technologies, LLC.

- High Power Super-radiant Mobile Antenna Project
- Development of high gain and high directivity S-band antenna capable of handling 10s of MW peak power, which can be installed on a tactical vehicle with a more than **5-fold reduction in aperture size**.
- Achieves >25 dB directivity, > 50% efficiency, small footprint, high peak power (20 MW), and fast steerability.
- A parallel concept development effort at W-band



# Non-Lethal Directed Energy Weapons Summary



- Provide operating forces with escalation-of-force options while minimizing casualties and collateral damage
- Always have lethal force overwatch/back-up
- Help fill the gap between shouting and shooting
- Offer options across the full spectrum of conflict



**Non-Lethal directed energy weapons capabilities assist operating forces in providing scalable controlled effects, minimize civilian casualties and reduce collateral damage**



# Department of Defense Non-Lethal Weapons Program

## Questions?

