High Power Radio Frequency Directed Energy Technology Opportunities and Challenges

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A Presentation to:
AOC Europe

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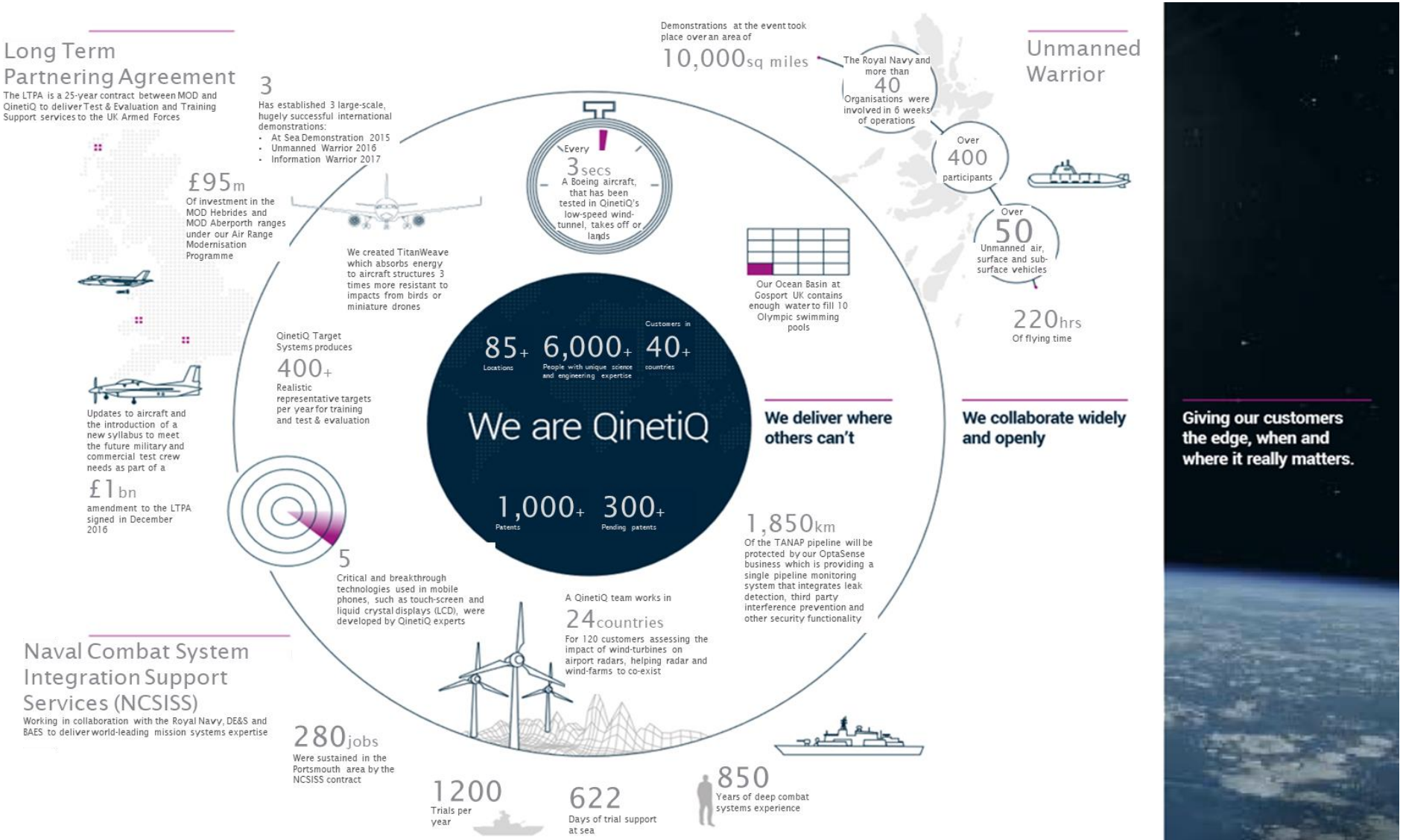
QINETIQ

Agenda

Introduction to QinetiQ

QinetiQ – the facts and figures



Our evolved strategy to increase focus and accelerate global growth

Vision

The chosen partner around the world for mission-critical solutions, innovating for our customers' advantage

Mission-led innovation

Create it — Test it — Use it

Customer focused growth strategy

Global leverage

Build an integrated global defence and security company to leverage our capability through single routes to market in UK, US, Australia, Canada, Germany and Belgium

Distinctive offerings

Co-create distinctive products and services to offer exceptional value for our customers in engineering, experimentation, test, training, information and autonomous systems

Disruptive innovation

Invest in and apply disruptive business models, digitisation and advanced technologies to enable our customers' operational mission at pace

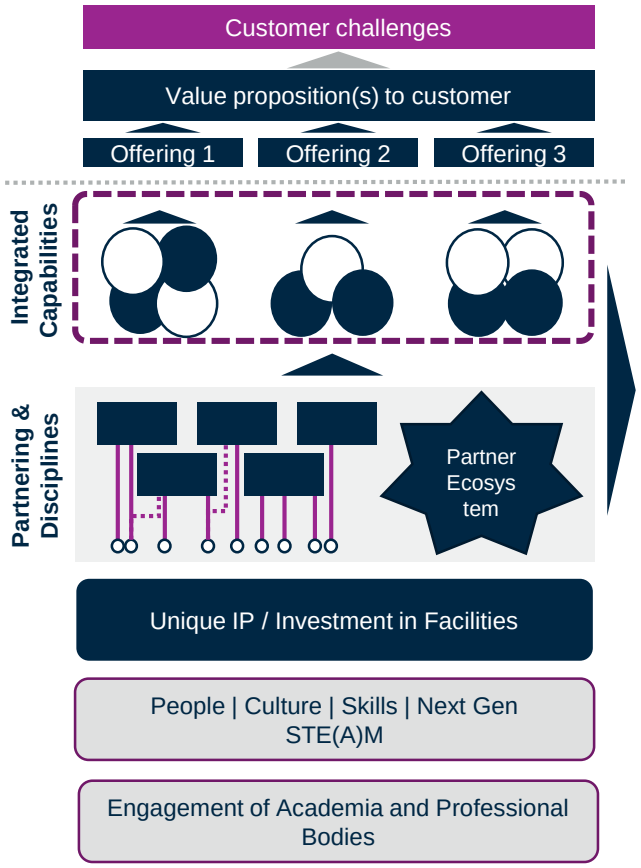
High performance inclusive culture

Our Values Integrity | Collaboration | Performance Our Behaviours Listen | Focus | Keep my promises

We deliver responsibly, sustainably and for the benefit of all our stakeholders

Developing game changing Capabilities: Providing value through innovation and experimentation with a continuous view on the future landscape and emerging threats

Capability Focus



IP ADVANTAGE IN S&T

Expand towards a highly technological and innovative future

OPPORTUNITIES & EXPERTS

Protect the technologies that will provide us with a decisive edge and prepare us for the future. Be the convenor of the UKs greatest experts for futurescaping

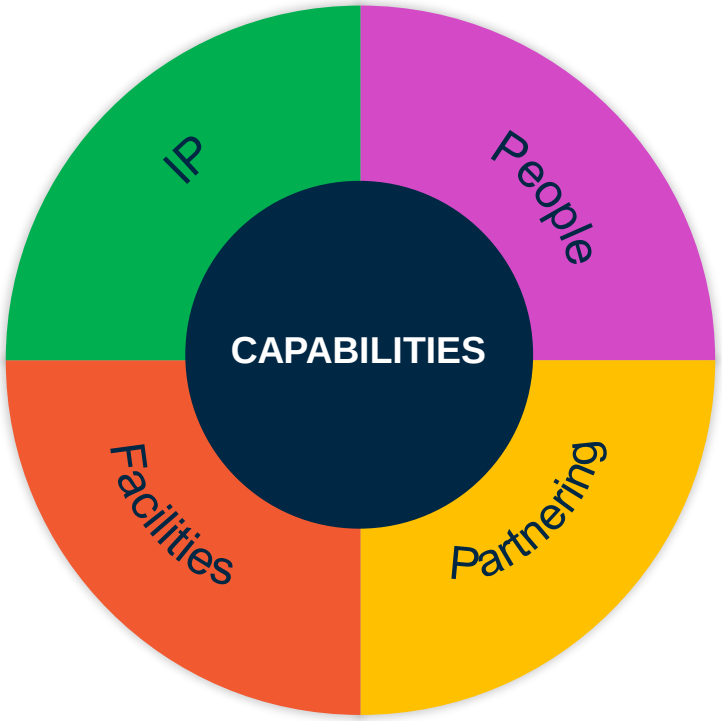
FACILITIES INVESTMENT

UK leader in S&T. A holistic systems thinking approach. Build Capability in the UK and promote overseas

UPGRADE & WORLD LEADING

Derisk projects, rapid experimentation, learning and exploitation. Do it faster and better than adversaries

QinetiQ Investments



Balanced Capability Portfolio

PEOPLE, SKILLS, TEAMING

New models for recruitment. Hire and develop talent from early careers, apprentice schemes, graduates. Develop Generation after Next technology skills

DIVERSE, INCLUSIVE CULTURE

Growth mind set, insatiably curious, open. Culture of continuous learning to meet evolving technological challenges

COLLABORATE AND SCALE

Seek Partners who are complementary and can fill gaps in QinetiQ

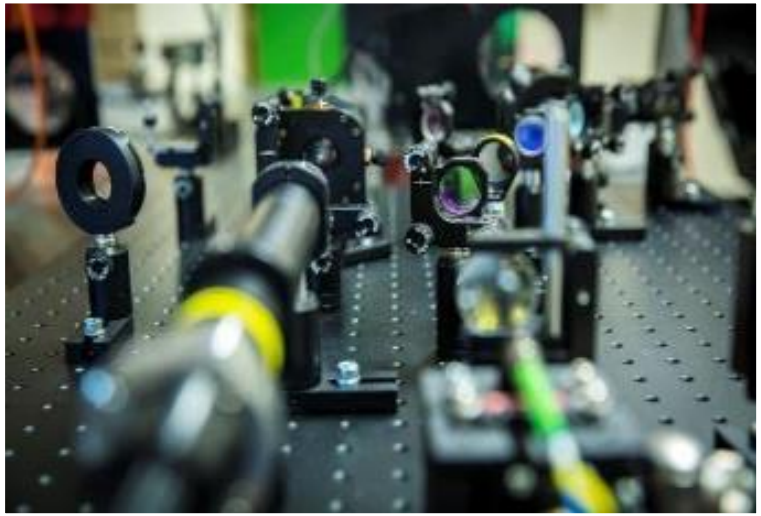
SME ECOSYSTEM

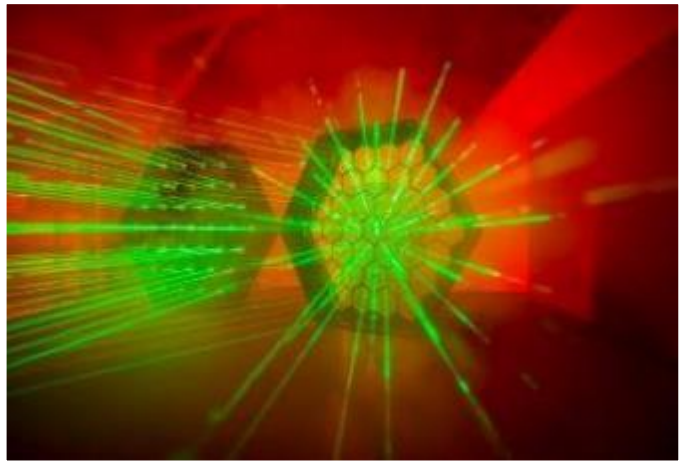
Hub of innovation, new developments, emerging disruptions. Leverage Ecosystems, breadth and depth across the Capabilities for the advantage of customers

Novel Effectors & Resilience

Strategy Summary

1. Development of a portfolio of innovative solutions and IP in Directed Energy Effector sub-systems and Resilience
2. Leveraging the strength of the Global QinetiQ business through collaboration to address organisational and process challenges
3. Working with partners to exploit our IP and innovative solutions

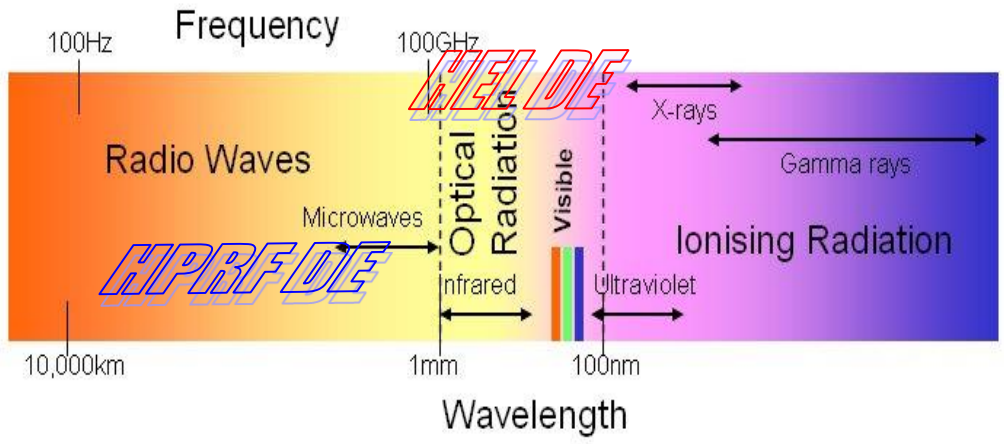




DE Scope, Applications and Benefits

Background

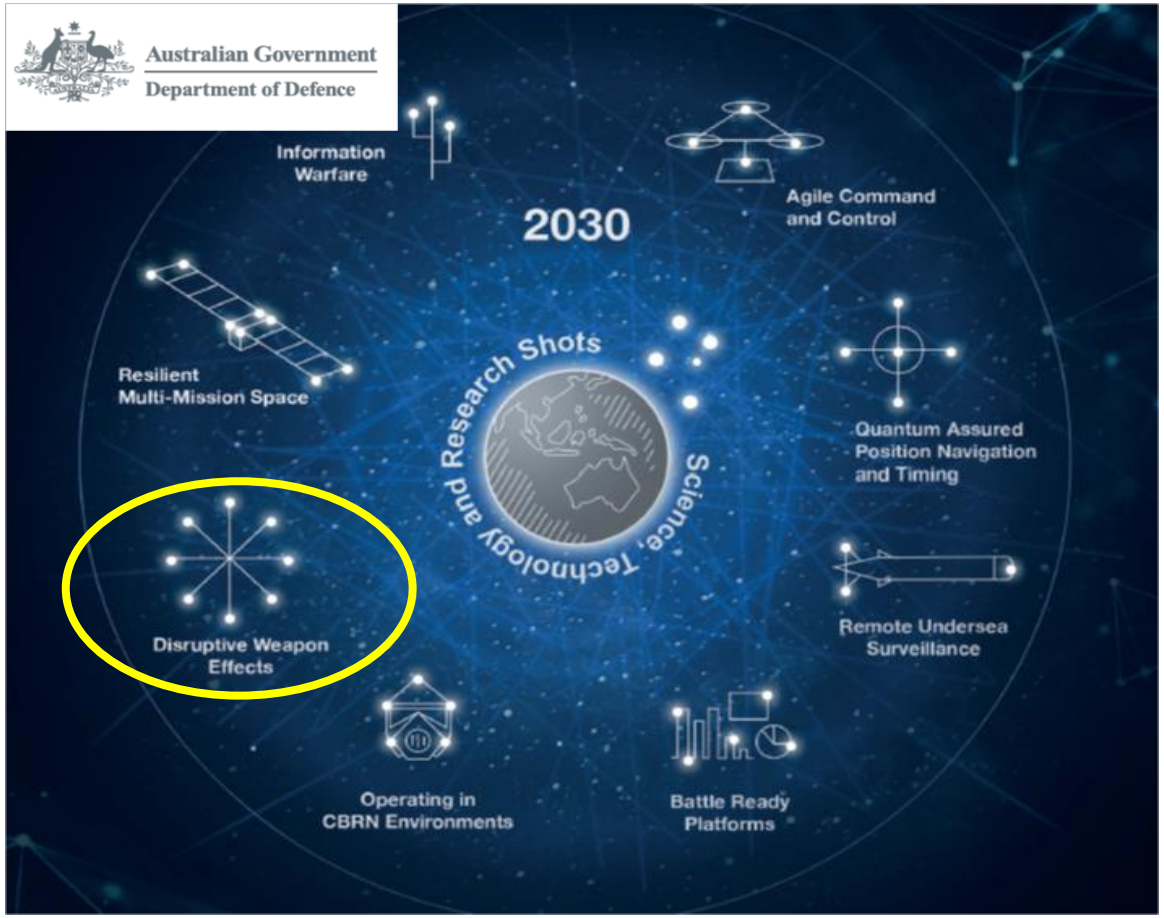
- DE is an emerging technology that is beginning to demonstrate military utility.
- The accepted US Department of Defense (DoD) definition of Directed Energy Warfare is:
  - ‘Military action involving the use of directed-energy weapons, devices, and countermeasures to either cause direct damage or destruction of enemy equipment, facilities, and personnel, or to determine, exploit, reduce, or prevent hostile use of the electromagnetic spectrum through damage, destruction, and disruption.
  - It also includes actions taken to protect friendly equipment, facilities, and personnel and retain friendly use of the electromagnetic spectrum.’
- DEW systems deliver energy to the target in some form, forms considered include;
  - High Power Radio Frequency (HPRF)
  - High Energy Lasers (HEL)
  - Ultra Intense Short Pulse Lasers
  - Particle / plasma / Novel techniques
  - Combinations of the above



DE Market? – UK MOD S&T Strategy, Australian DOD STaRShots as a lens

In consultation with Users, we identified five strategically-vital areas that can be disrupted through science and technology:

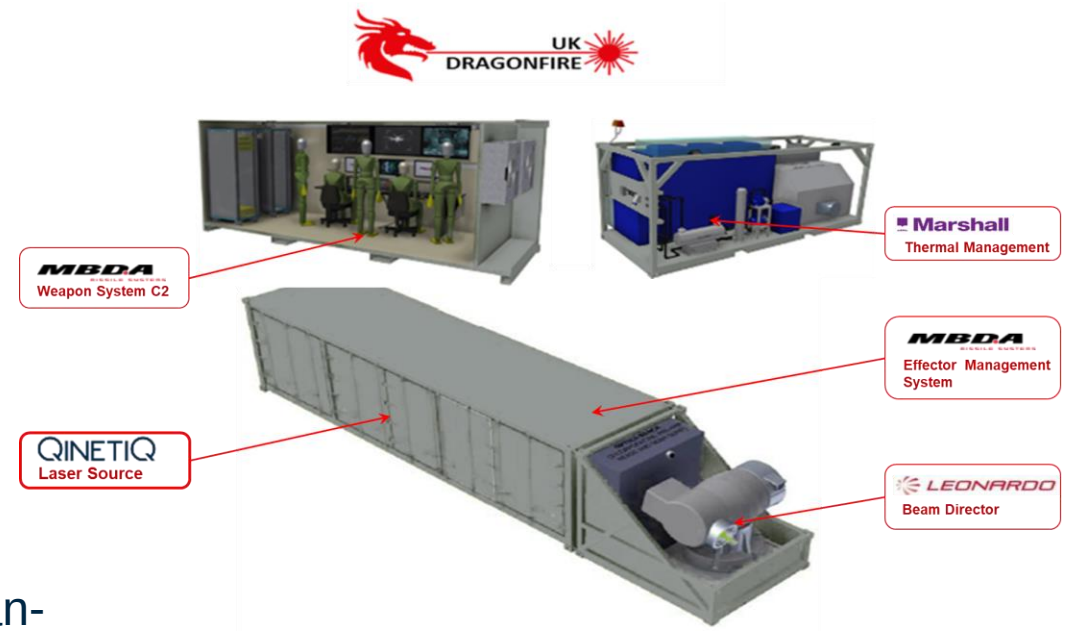
Pervasive, full-spectrum, **multi-domain ISR**	Multi-domain **command, control, communications and computing**	Secure and sustain advantage in the **sub-threshold**	Asymmetric **hard power**	**Freedom of access** and manoeuvre
Responding to threats and opportunities of current & emerging technologies affecting our ability to conduct ISR in all in domains & environments.	Develop the capability for multi-domain integration and coordination of effects; executing joint operations vs adversaries with better-integrated, more resilient, secure capabilities.	Improve the UK's ability to compete below the threshold of conventional conflict, primarily in the information environment.	Counter and adopt highly capable weapons systems and effectors (e.g. DEW, hypersonics) to increase advantage against adversaries across key domains.	Effective and affordable counters to capable, long-range, networked systems that limit our access and ability to manoeuvre in both traditional and new domains



DE Technology (Effectors and Resilience) is a core theme to Global Defence S&T Strategy for next 10 years

Benefits of DE over Conventional Kinetic Weapons

- Deep magazine
- Low cost of engagement, especially for stealthy or low cost proliferating targets
- Speed of light attack
- Rapid re-targeting
- Smaller logistical footprint
- Flexibility of engagement effect, including nonlethal and less-than-lethal
- Smaller Collateral damage footprint
- Low visibility attack
- Scalable Effect



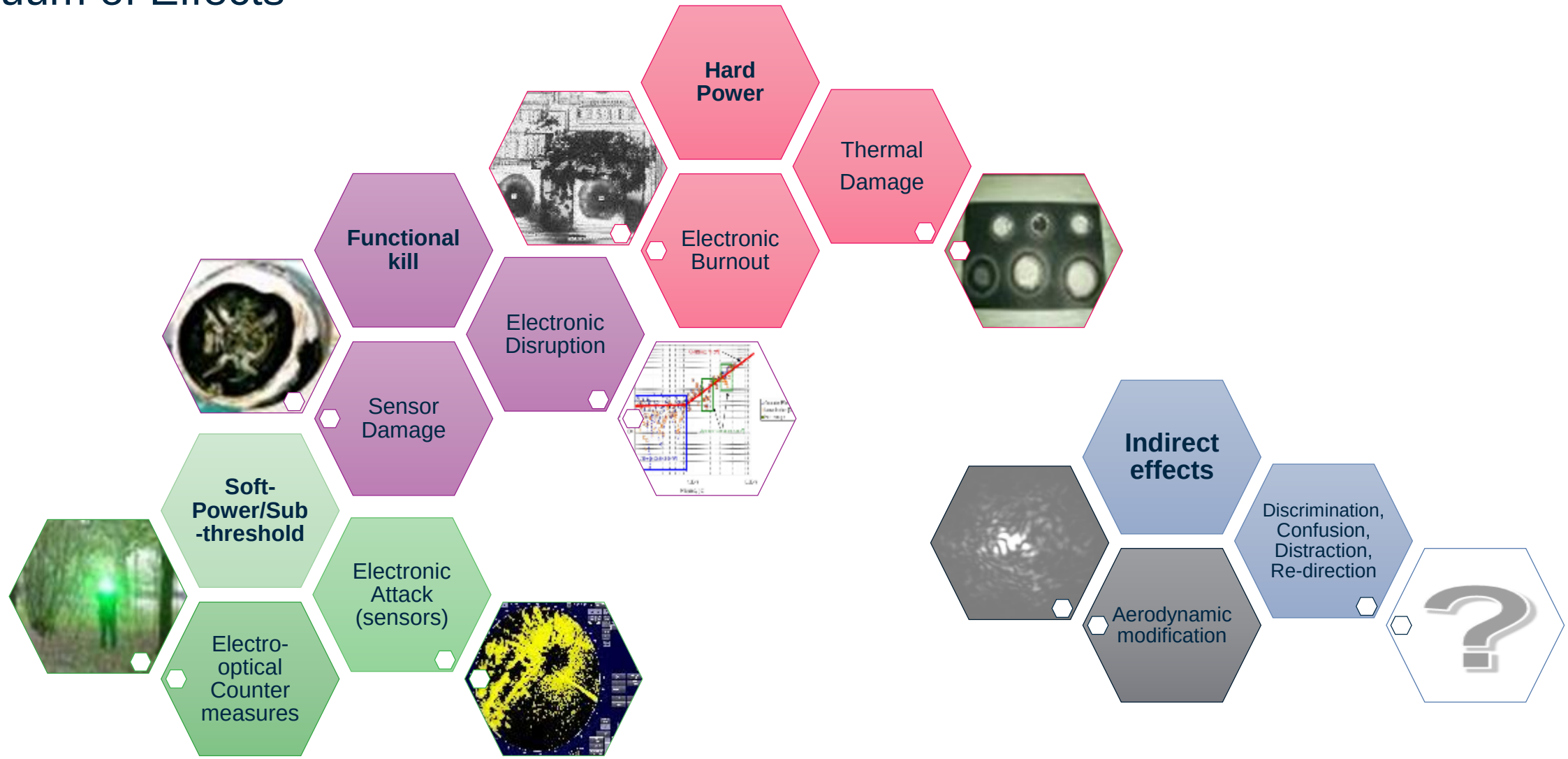
HEL and HPRF DE Systems technologies are on the threshold of becoming operationally relevant for us and our potential adversaries

Worldwide DE Systems Application Areas and Maturity

Application area	HEL	HPRF
Ground & Ship Based Air Defence (GBAD/MLAD/C-UAV)		
Counter-Rockets, Artillery, Mortar (C-RAM)		
Counter Improvised Explosive Devices & Explosive Ordnance Disposal (C–IED/EOD)		
Deep Target Attack (DTA)		
Vehicle/Vessel Stopping (C-Mobility / C-FIAC)		
Special Forces		
Cyber/CEMA		
C-Personnel		

HPRF Effects

Continuum of Effects



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‘Jamming’ or ‘soft kill’ effect

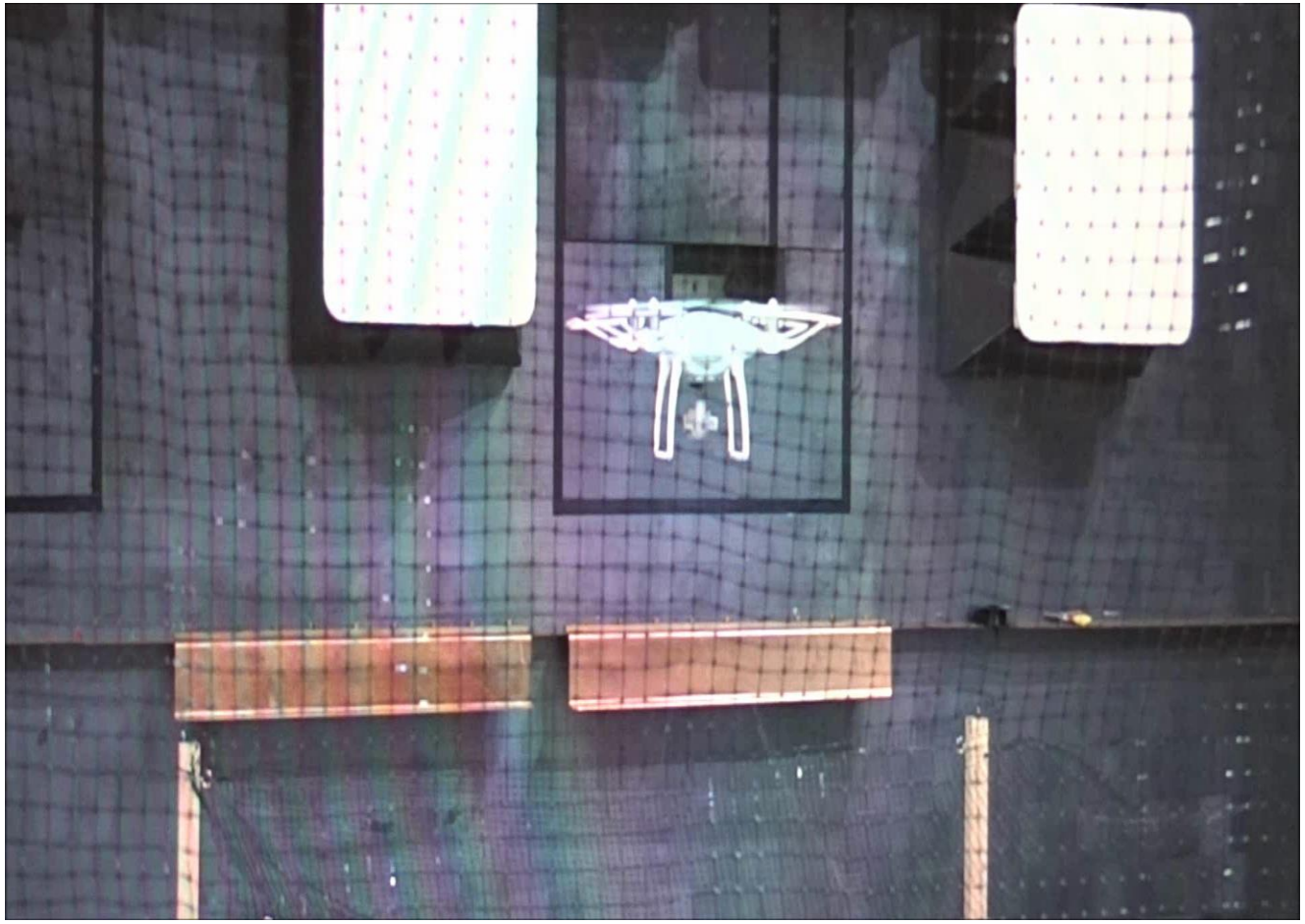
- After prolonged exposure, UAV either ascends (to find a signal) or carries out a controlled descent
- **Advantage:** possible use as a deterrent
- **Disadvantage:** Will not deter the motivated pilot/pilot who has employed autonomous flight
- **Disadvantage:** Requires the RF exposure to be near continuous prolonging the risk for collateral effects
- **Advantage/Disadvantage:** UAV is not permanently incapacitated, can take off again once jamming removed

‘Active Deterrence’ effect

- Video feed interference
- Repeat compass error warning message
- **Advantage**: Anti-surveillance and disorientation of the pilot through video interference
- **Disadvantage**: Likely to be a variable response depending on the UAS software configuration

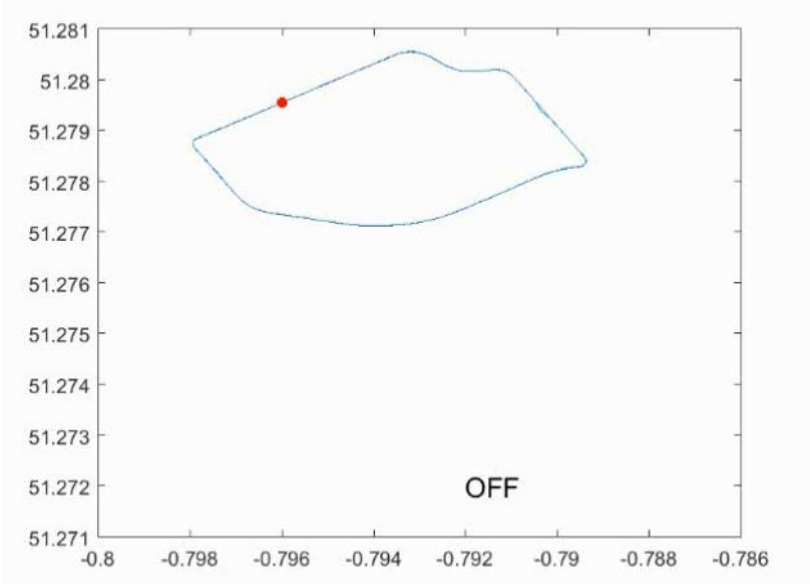
‘Hard Kill’ Engine defeat effect

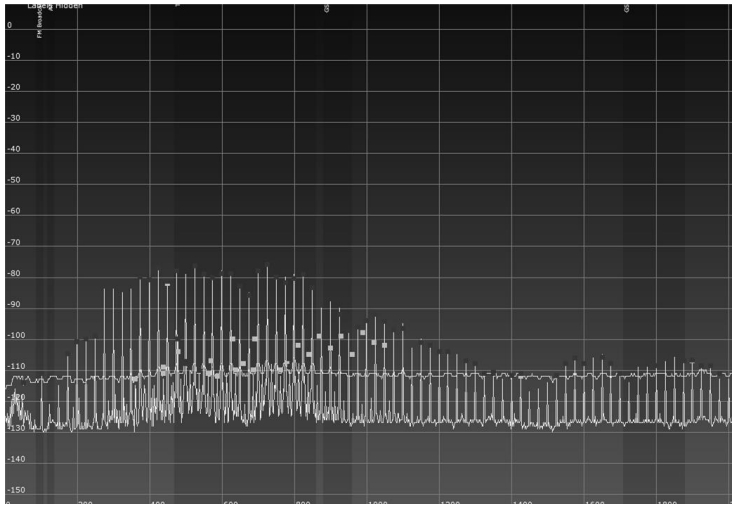
- Montage of ‘hard kill’ effects seen
- Direct upset of electronic systems – engine speed controller 70 to 80% common to most mini UAV models
- **Advantage:** Very short exposure time required (less than 1 second) – minimal collateral if configured correctly
- **Advantage/Disadvantage:** UAV is permanently incapacitated
- **Advantage:** Defeat of UAV in autonomous flying mode
- **Advantage:** Defeat of UAV swarms (cooperative and uncooperative)

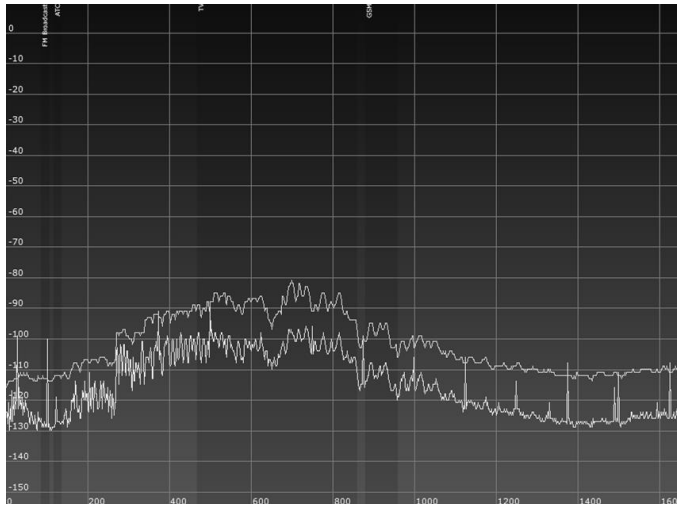


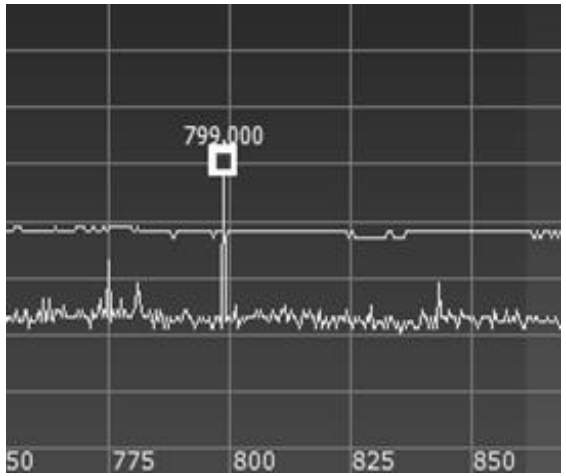
Detectability

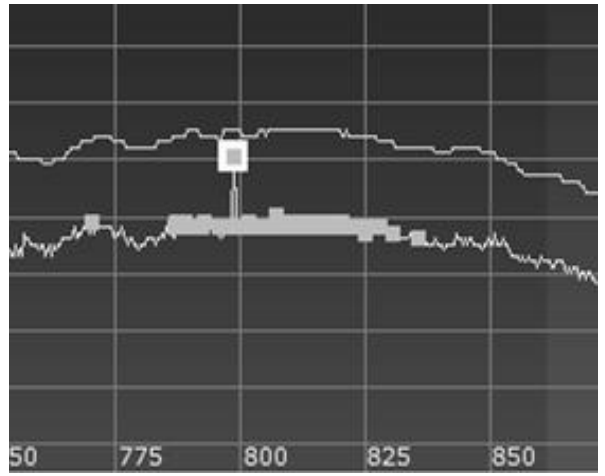
- Experimentation on digital communications systems:
  - GNSS (GPS & GLONASS)
  - Wi-Fi
  - ESM systems
  - Combat Net Radios
- Detection of Hyperband HPRF DE using an ESM receiver









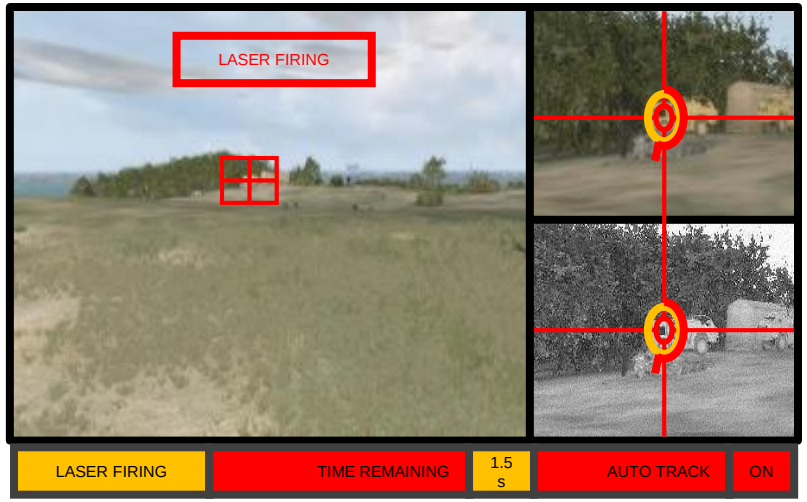


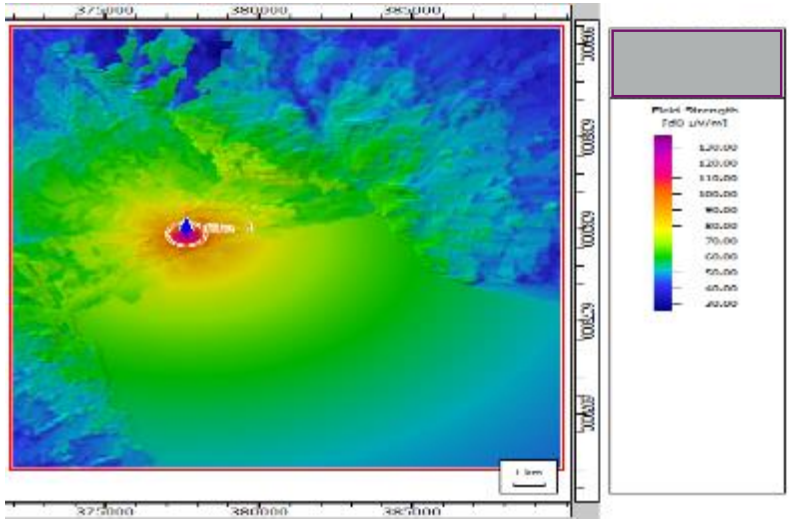
Challenges for Directed Energy

Challenges for HPRF DE

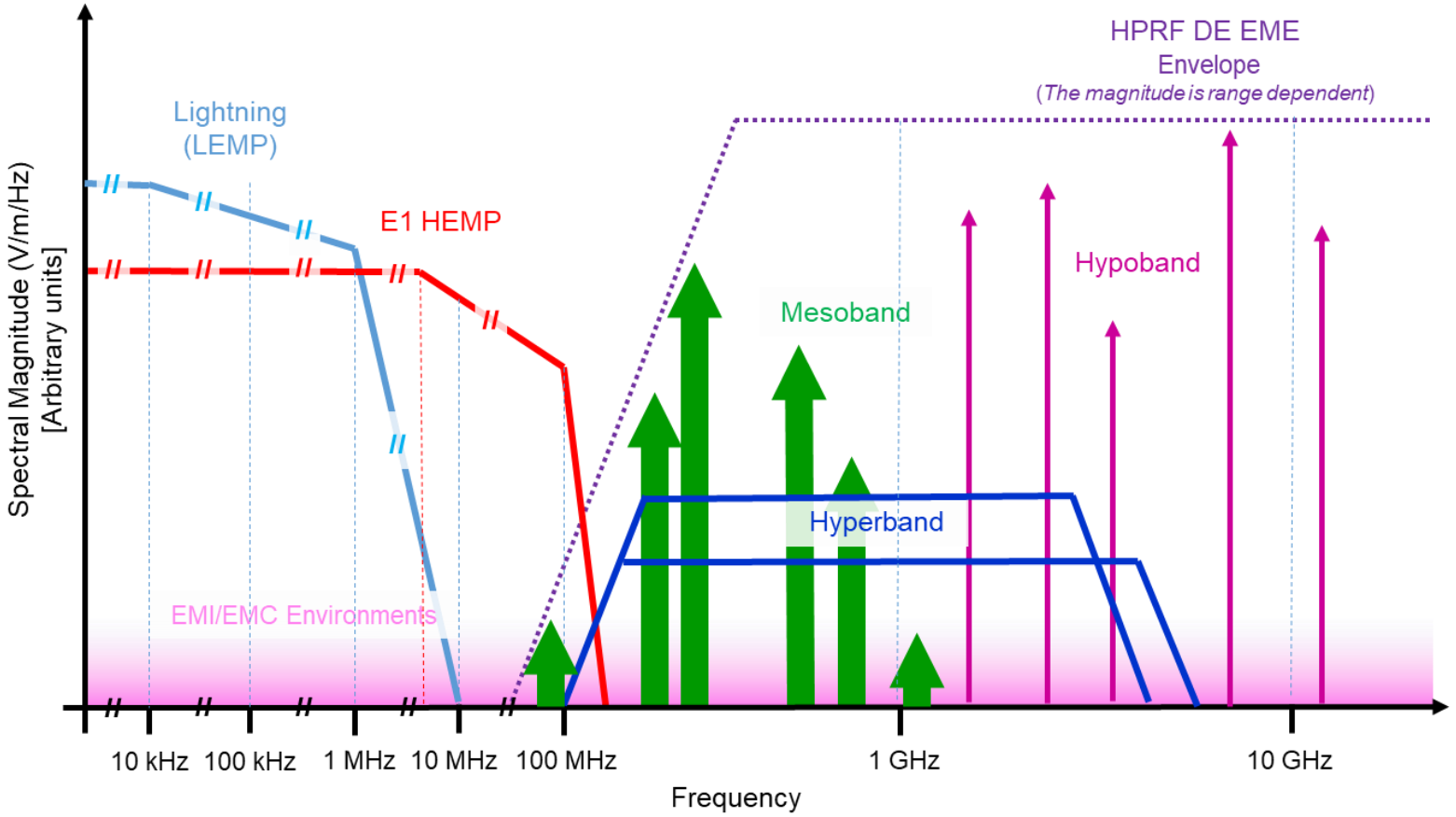
- Stove-piped research
- Technology Challenge – SWAP
- Platform Integration
- Doctrine/RoE/Legal
- Military Readiness/Acceptance (Training)
- Operational Analysis (Targeting)
- Safety Case/Collateral Effects/Battlespace Interoperability
- Resilience & Protection
- Capability Assurance (T&E)

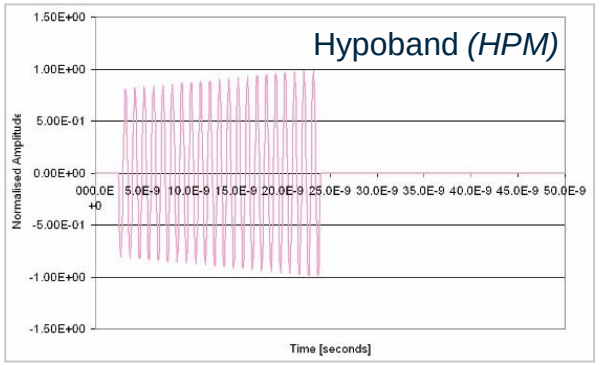
HEL Simulator/Trainer

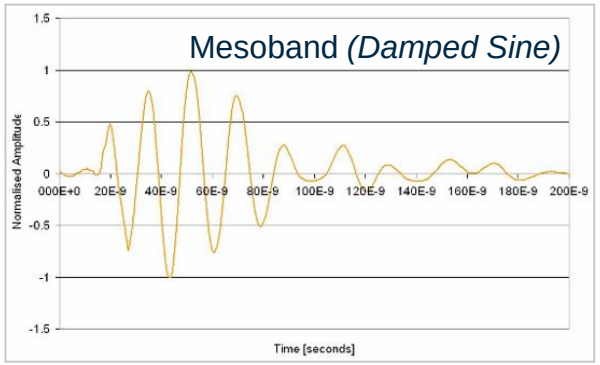


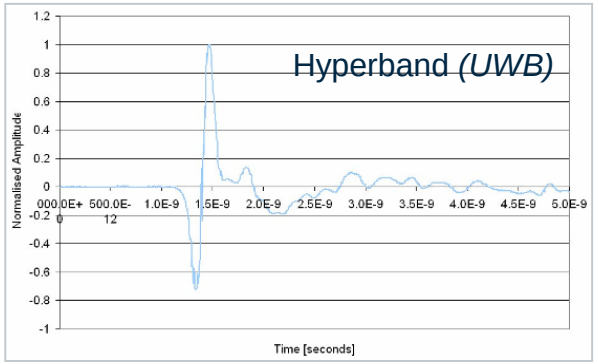


Defining the Environment



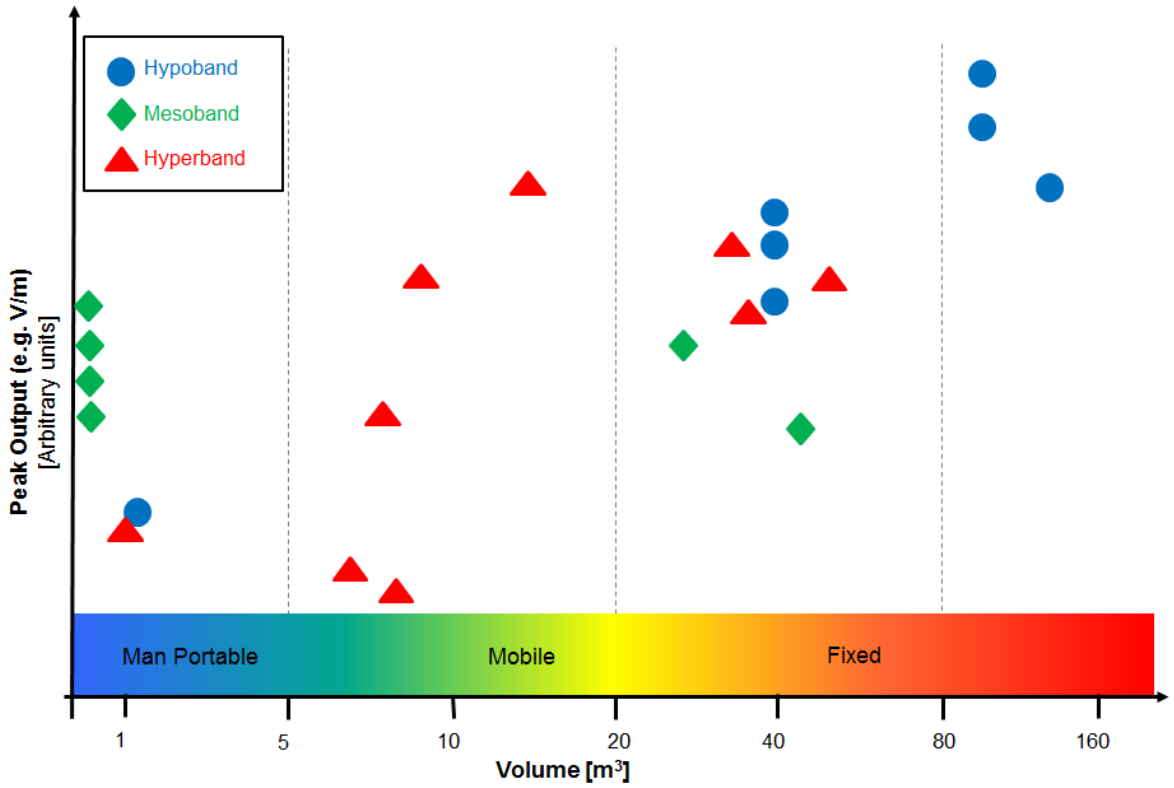






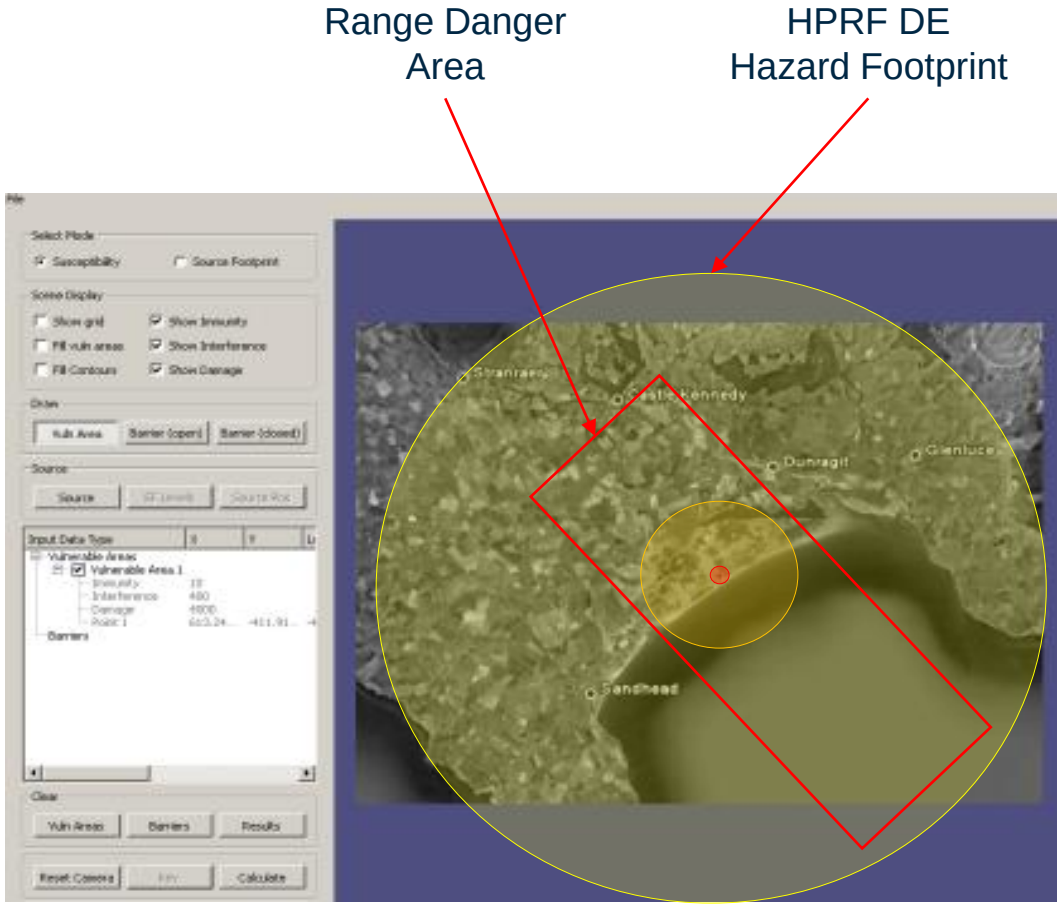
Defining the Environment - Standards

- NATO AECTP Leaflet 257 **Edition 3: HPRF DE Systems**
- NATO UNCLASSIFIED
- Published October 2019
- Example “friendly” applications of HPRF:
  - Countering UAV’s from a fixed site or mobile platform;
  - Countering the mobility (engine-stopping) of vehicle or vessels, probably from a pursuit vehicle or vessel;
  - Countering Improvised Explosive Devices (C-IED) in a rolling convoy and;
  - Targeting hostile command control systems delivered from a HPRF payload mounted within a large missile or UCAV.
- The use of HPRF sources by NATO Alliance partners may cause unintentional consequences to partner assets.
- Hostile applications of HPRF:
  - long and short range air defense from a large vehicle or installation; or
  - other more subversive means to attack critical civilian or military assets



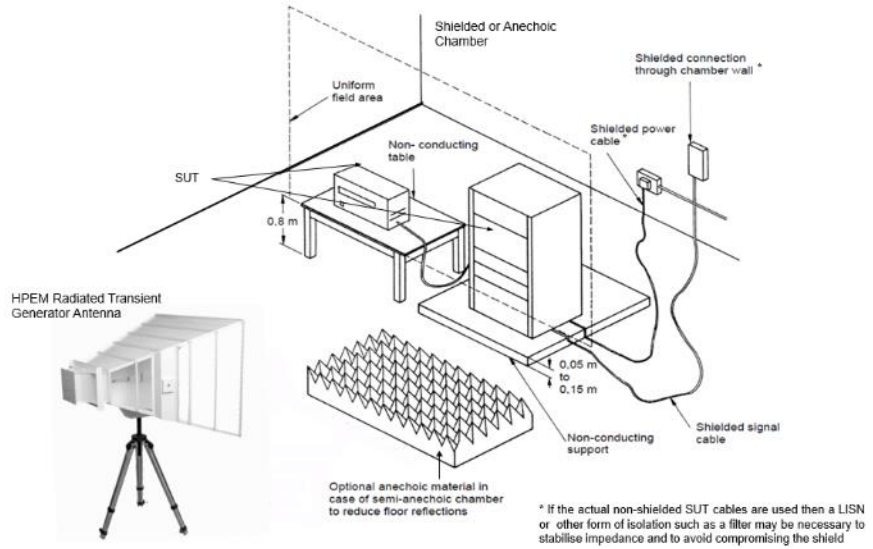
Challenges for DE – Collateral and Interoperability

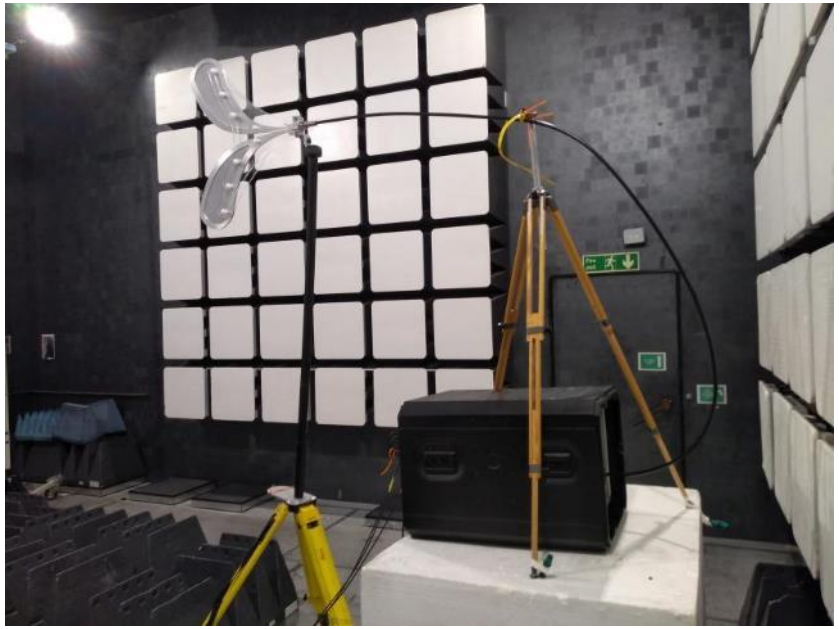
- How do you quantify the risk (to Civilian and military infrastructure on and off range) well enough to build a safety case (
  - Absence of a large body of evidence?
- Lack of evidence leads to significant constraints when trialling DE Outdoors;
  - Has a profound impact on DE System acceptance and use of DE in-service
- Evidence required for the impact of DE on materiel not specifically targeted (HPRF hazard footprint,).
  - Sensors & Receivers (jamming); Ordnance, EED's; Flammable Atmospheres; Safety Critical Electronics – Automotive, CNI, Aircraft; People.



HPRF Immunity Test Solution - PULSR

- Features:
  - Adaptable by antenna change to produce Mesoband and Hyperband waveforms
  - Capable of operation inside a SAC or outside – Portable
  - Safety Arming and Firing System
  - Adjustable amplitude
- Adjustable Pulse Repetition Frequency (prf):
  - 1 Hz to 1 kHz
- High pulse fidelity reproducibility/repeatability
  - Less than 0.5dB mean amplitude pulse to pulse repeatability
- Mesoband:
  - Max E-field: ~2.4 kV/$m_{pk\text{-}pk}$ @ 3m
- Hyperband:
  - Max E-field: ~16 kV/m_{pk} @ 3m





Resilience and Protection – A comment on Technical Capability

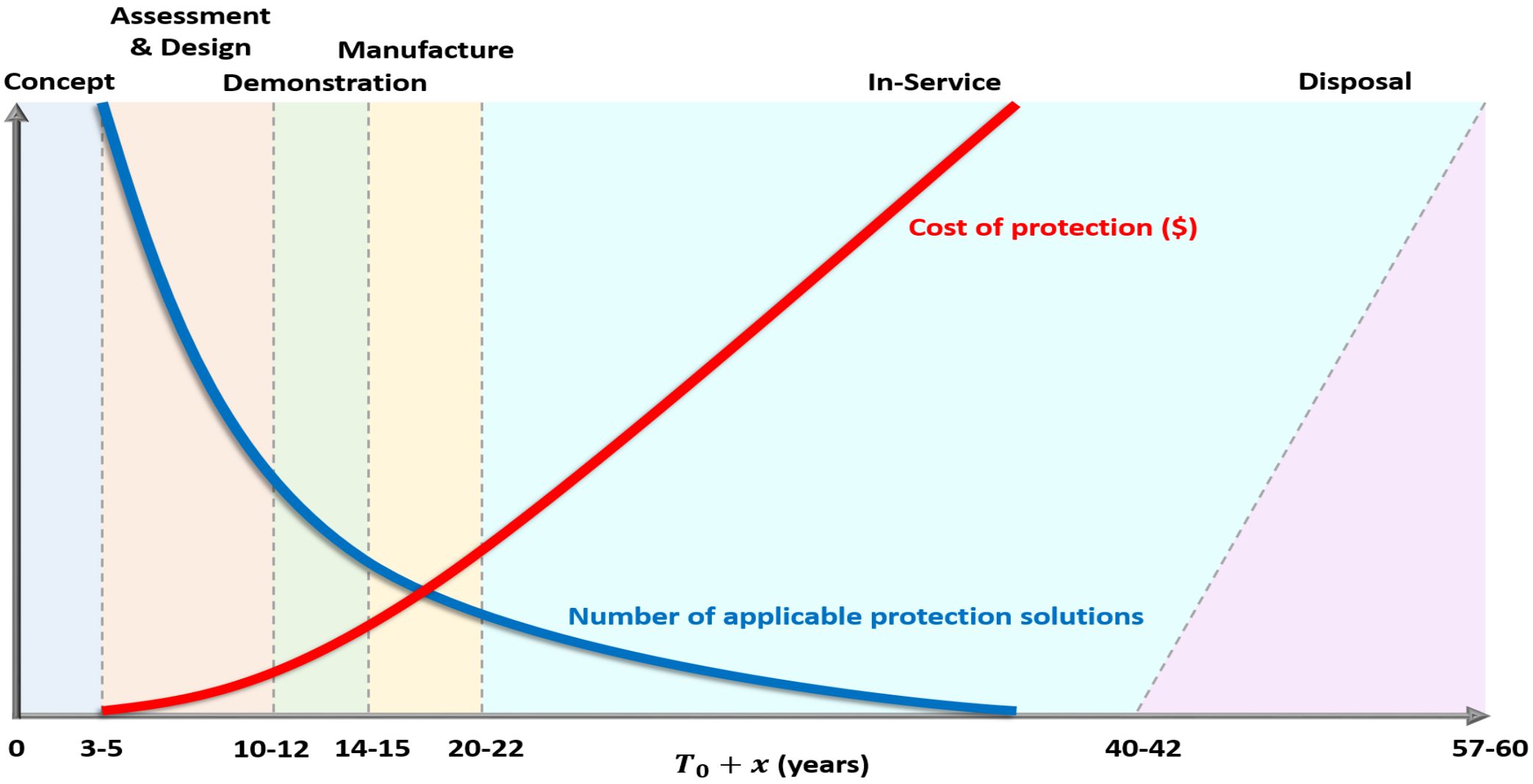
- Many nations are developed HPRF DE capabilities;
  - China; Columbia; France; Germany; Sweden; Israel; Italy; Netherlands; Republic of Korea; Russia; UAE; UK and USA
- The technical capabilities of some nations (e.g. China and Russia) are advanced
- Some nations are progressing different applications for HPRF DE capabilities
  - Anti-Personnel; C-ISTAR
- What about our own DE Effectors or those of our Partners (Blue on Blue risk).
- The existence, already, of seemingly capable systems should be of concern to us now.

The Chinese SilentHunter LDEW Anti-Drone System

Russian Tor-M2U anti-air missiles systems

Disclaimer: Our observations are based on deep technical review of open source material only

Why Now?



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Summary

Summary

- DE Systems have been and continue to be, a focus of military research and development in the UK and in many other countries Worldwide.
- HPRF DE Systems have been used in Military operations on a small scale
- HPRF DE can provide EA ‘like’ effects through to harder effects
- DE Systems are on the threshold of acceptance into military service
- There are still many challenges to overcome and in particular significant efforts are needed to address:
  - Collateral,
  - Safety,
  - Interoperability,
  - Platform resilience and
  - Capability assurance
- Significant research efforts are needed to overcome some of these non-technology challenges and unblock acceptance

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