QINETIQ

Directed Energy Effector Systems

The challenges of Directed Energy

How do we solve the transition of Directed Energy from demonstration into service?

Directed Energy (DE) Effector technologies such as High Energy Lasers (HEL) and High Power Radio Frequency (HPRF) systems have some unique abilities and advantages.

They will bring new ways of working for Defence customers – from procurement and acquisition through to military operations. They will be effective in rebalancing the threat from low cost and sub threshold actions such as Unmanned Air Vehicle (UAV) swarms and Fast Attack Craft (FAC), or challenging Asymmetric hard power threats such as hypersonic missiles, whilst doing so in an affordable, safe and low environmental impact manner. DE Effectors will need to work alongside conventional weapons in the future.

QinetiQ has been at the forefront in development of world-leading HEL technologies, has promising concepts in HPRF and is conducting research into other DE technologies.

However, a justifiably conservative approach to collateral risks is preventing DE experimentation outdoors on Ranges in the UK and slowing progress.

The UK MOD Science & Technology (S&T) Strategy is set to assign an increase in budget for DE under the Asymmetric Hard power theme. The United States and Australia are investing heavily in DE technologies, but so are our key adversaries. The Middle East is experiencing the threat from UAVs and UAV swarms today and countries such as Turkey and Israel are innovating DE solutions. Technologies needed to support DE effectiveness such as precision optics have spin-out value to other defence and civilian applications.

The following steps would advance DE technology maturation and exploitation:

- A multi-year funding plan for DE Innovation, maturation and exploitation. The new MOD S&T Strategy appears to address the innovation and maturation need but industrialisation and prototype manufacturing also require investment.
- Investing in game-changing HEL technology to secure Intellectual Property for the benefit of the UK and secure export opportunities, principally in Australia and the Middle East.
- Focussing efforts on enabling outdoor trials and experimentation of DE on the UK Test and Evaluation (T&E) Ranges thus enabling DE technology to accelerate towards full maturity. Understanding collateral effects and interoperability with infrastructure is key.
- Supporting UK manufacturing industry to provide an indigenous supply chain for high power fibre laser amplifiers, coatings and optics. This support could come from non-MOD Research & Development initiatives.

Directed Energy Technologies offer new ways to project hard power but that's not all…

Directed Energy (DE) has been a field of research since the late 1960's and has always offered promise as a revolutionary way to defeat or defend against difficult targets.

The most mature DE technologies are;

- High Energy Lasers (HEL), sometimes referred to as Laser Directed Energy Weapons (LDEW) and
- High Power Radio Frequency (HPRF) systems, sometimes referred to as RFDEW (Radio Frequency Directed Energy Weapons) or High Power Microwaves (HPM).

Primers describing various features of HEL and HPRF systems have been published in a separate paper.

There are also other promising technologies of lower maturity such as Ultra Intense Short Pulse lasers and particle beam systems.

DE effector technologies possess some unique abilities and advantages over traditional weapon concepts such as:

- **Rebalancing Asymmetry** – Low-cost threats including UAV swarm threats can be neutralised economically.
- **Defeating targets that are difficult to defeat with conventional weapons** – DE delivers an effect on a target with precision at close to the speed of light which will be beneficial for the defeat of very high speed threats such as hypersonic missiles.
- **DE effects can be 'dialled up and down'** – this means that effects can be exploited from sub-threshold, through intermediate force to hard power.
- **DE is electrically powered** – this means the effect can persist as long as electrical power is available. This is sometimes referred to as deep magazine. The DE ammunition 'stockpile' is electrons stored in a power supply or battery.
- **DE is ever ready** – because electrons are the ammunition as long as there is an electrical supply then the effector is ready to fire. This contrasts with traditional weapons where a platform may have to return to base for ammunition replenishment.
- **Lower Carbon footprint** – DE dispenses with the need to manage explosives. For conventional weapons the whole life management of explosives requires an expensive, safety critical logistical trail from carefully tailored handling processes, extensive assurance requirements, stockpile management and the need for disposal.
- **DE lends itself to an agile development approach** – For example a minimum viable DE capability could be fielded and then the power, and hence range and effectiveness, can be increased over time as part of an iterative process. Alternatively a minimum viable solution could be deployed to gather learning from user experimentation to improve command and control and to refine tactics, techniques and procedures. The ability of DE technology to accept the twin concepts of a minimum viable solution and agile iterative performance enhancement are not possible with traditional weapon system.

HEL and HPRF effectors are next generation technologies and are capable of transition in to service. Other less mature aspects of DE truly fit the 'generation-after-next' Science & Technology model. There is no doubt that DE effectors will play a complementary role to traditional weapons in a modernised defence organisation.

QinetiQ has some world leading innovative concepts and sub-system technologies that significantly enhance DE effect capability such as a proven HEL coherent beam combining architecture which is discussed in a separate paper.

Let's not forget that we don't have a monopoly on DE effector technology

Protection and resilience from our Allies and in particular our adversaries with the use of DE is a vitally important consideration. Some of our adversaries are very active and quite advanced in their DE effector development programmes.

Whilst our S&T efforts have been focussed on Effector development, a whole host of protective materials, DE Armour, will be needed and QinetiQ has begun to explore this requirement.

The survivability of UK assets from a DE exposure in all domains including Space is an important requirement that must be addressed now in order that UK assets are not held at risk from our adversaries' use of DE in the future.

QinetiQ and our other UK industry partners have invested in DE technologies

QinetiQ has invested in and developed a significant capability inDE. We also have facilities such as anechoic chambers for HPRF DE experimentation and the DragonWorks facility for HEL integration and testing.

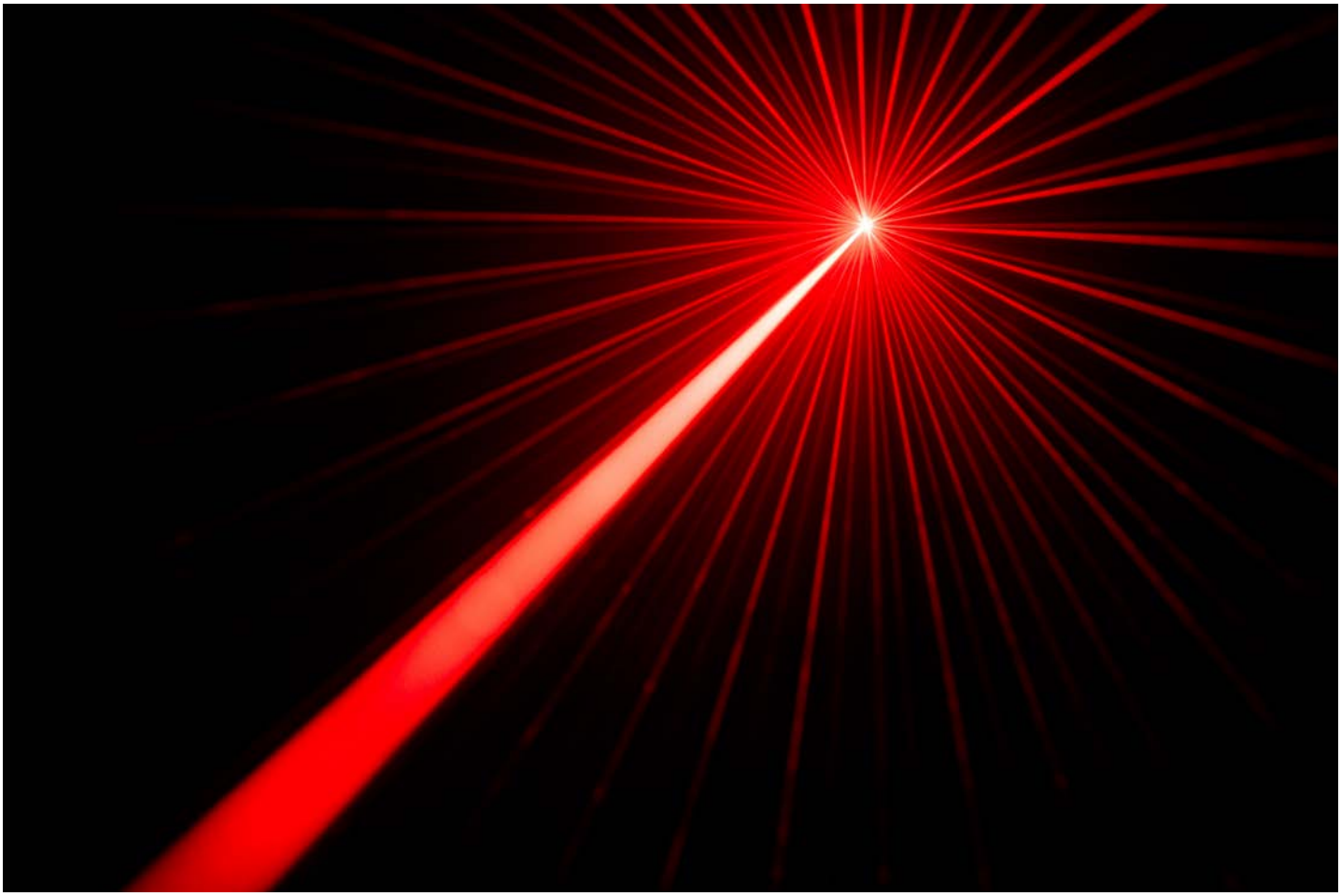
In the specific case of HEL, QinetiQ has:

- HEL Coherent beam combining which can deliver greater power at the target and overcome some atmospheric effects.
- Target classification and aim-point maintenance algorithms which substantially reduce the HEL engagement time
- Long term kW class high energy laser experience with a good track record of delivering success to our customers
- A well-developed atmospheric laser propagation modelling capability, verified by experimentation on a limited set of range trials
- Investment in lab based testbed, simulating a coherently combined phased array laser operating through atmospheric turbulence

QinetiQ worked with its principal partners, Leonardo, MBDA, and Marshall Aerospace and Defence on the UK MODs LDEW concept demonstrator “Dragonfire”. This programme is managed by our colleagues in Dstl as are many other DE S&T efforts.

As part of the LDEW CDP QinetiQ has successfully built and tested our 50kW coherently combined laser. This is thought to be a world first for coherent beam combining at this power level. The Dragonfire Laser effector source is expected to deliver power and accuracy beyond those demonstrated by other nations.

Outside of the LDEW Programme, QinetiQ has begun work on the full gamut of S&T needed to progress DE technologies from compact electrical power sources, through to lethality and back to understanding the reflection hazard on the human eye.



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