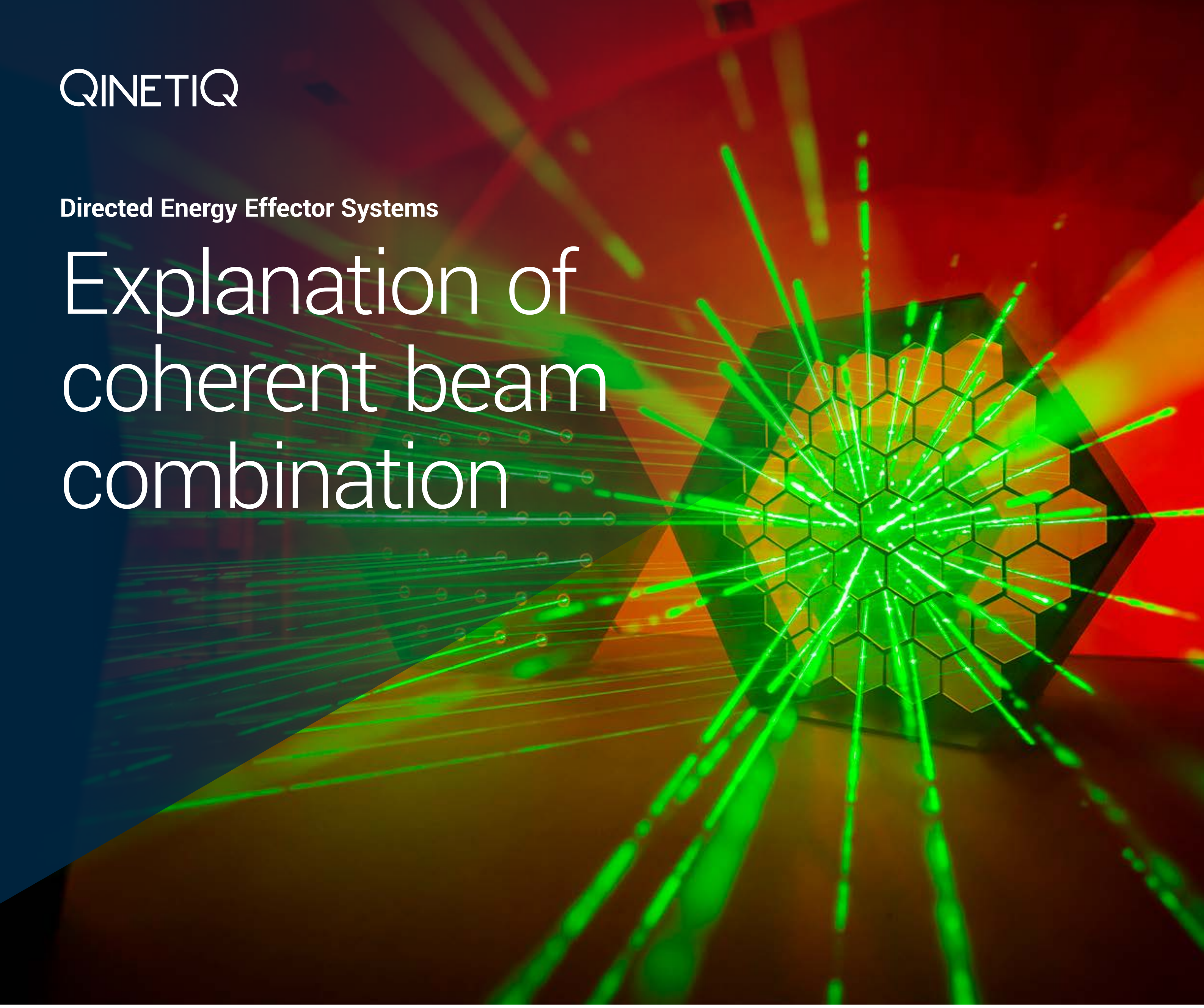


QINETIQ

Directed Energy Effector Systems

Explanation of coherent beam combination

A game changing technology that enables delivery of more power on target

Most discussions connected with High Energy Lasers (HEL) and Laser Directed Energy Weapons (LDEW) systems, even today, is simplified to classifying the Laser effectiveness by the power at the source. This is usually in tens or hundreds of kW level.

However, QinetiQ scientists recognised more than 20 years ago that the vital parameters were power at the target and other beam properties at the target. It is, after all, at the target where Directed Energy (DE) takes effect.

Leading HEL programmes in the 1970's and 1980's were achieving very high powers at the laser source for example, the MIRACL laser is quoted as producing 1 Megawatt for 70 seconds burst. However, those very high power lasers were not seeing effects improve with range in the manner expected.

This was attributed to thermal blooming, the sheer power of the laser was heating the atmosphere between the laser and the target and this process attenuated the beam power at the target.

These older very high power lasers such as MIRACL and the Airborne Laser (ABL) were also 'monolithic' i.e. a single source of laser energy is used to create the beam. In the case of both of these a very nasty concoction of toxic liquids and gases were used or produced by the laser source

Fibre Laser Amplifiers began to be developed in the mid 1960's but could only produce a milliwatt or so of power. It wasn't until the 1990's that a few Watts could be produced by fibre lasing. Today a few kW's of power is achievable by a fibre laser and all of this development has taken place for industrial applications such as laser drilling, cutting and welding.

The LAWS system was perhaps the first laser to demonstrate that connecting several lower power lasers together to create more total power was a practical way forward for the more demanding challenge of LDEW.

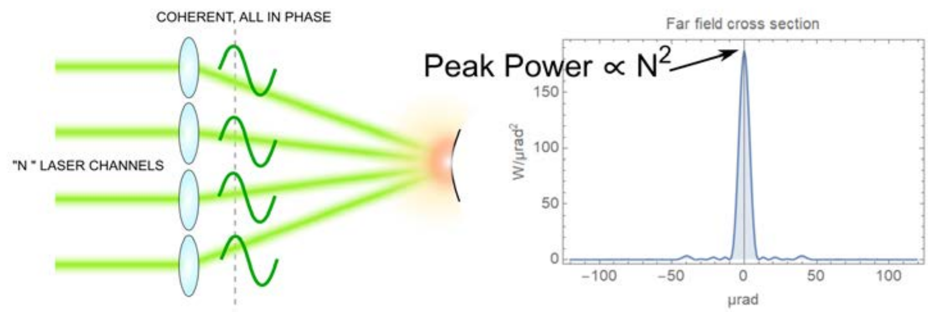
From a defence perspective where the laser has to be operated in a harsh environment e.g. on board a ship, a laser that is composed of several lower power modules makes complete sense where Availability, Reliability and Maintainability are key drivers.

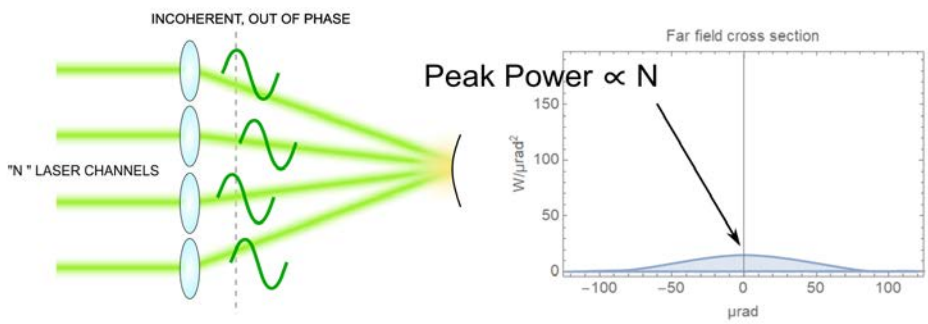
For a monolithic solution if the laser source fails then the laser is no use. For a distributed source fibre laser, if one laser module fails, then the laser still has some capability.

The key question becomes what is the most efficient way to connect the distributed low power laser sources together? There are many techniques, such as spectral for this but most result in incoherent combination of multiple beams.

The QinetiQ approach is to apply local phase-locking to produce coherent combination of multiple lower power laser sources. This approach was first demonstrated at low power in a lab setting under a UK MOD project called PP-FLAME in 2011-2012 using a bundle of fibre lasers as the source. Experiments under the AMBER programme in 2015, at the laser test facility at MOD Shoeburyness proved that it was possible to propagate a phase-locked beam over 2 km, outdoors in challenging atmospheric conditions.

Phase locked beams create a brighter central spot which is important for effectiveness. The key effector sub-system that manages this phase-locking or coherent combination is the beam combiner. How QinetiQ implements the mechanism inside the beam combiner is the interesting part. Through the LDEW Concept Demonstrator Programme (CDP) as part of the UK Dragonfire consortium, QinetiQ have implemented a beam combiner technology which is demonstrating interesting capabilities.





Incoherent combination does sum the power from each laser source but does not sum as efficiently as phase locked – coherent combination

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