EUROPEAN POLICY CENTRE

POLICY BRIEF

EUROPE IN THE WORLD PROGRAMME

4 JUNE 2025

Directed Energy Weapons and the Future of European Defence

Chris Kremidas-Courtney

INTRODUCTION

Europe stands at the edge of a new defence frontier defined by beams of light and pulses of energy. As warfighting evolves into the age of mass precision, the weapons that will shape tomorrow's battlefield may not make noise or leave shell casings behind.[1] Directed Energy Weapons (DEWs) are no longer science fiction, since they are rapidly becoming a vital element of European air defences. As Europe faces intensifying threats ranging from drone swarms to missile attacks, DEWs offer rapid-response, low-cost-per-shot solutions that can intercept threats at the speed of light.

DEWs, which include high-energy lasers, high-power microwaves (HPM) and particle beam systems are emerging as transformative capabilities in 21st-century defence. They employ electromagnetic or photonic energy to disable or destroy multiple targets with remarkable precision, unlike kinetic munitions that rely on ballistic interception. Lessons from the invasion of Ukraine and the Red Sea Crisis tell us that Europe requires these capabilities now.

THE STRATEGIC VALUE OF DIRECTED ENERGY WEAPONS

European militaries are adapting to a modern battlefield dominated by drone swarms, hypersonic missiles and loitering munitions. DEWs, such as high-energy lasers and HPM systems are being integrated into air and missile defence plans as cost-effective replacements for missile-based interceptors. Their ability to neutralise small fast-moving targets such as drones, rockets or loitering munitions offers key advantages to the defender.

Lasers can strike targets with pinpoint accuracy, generating almost no collateral damage and at costs as low as a few euros per shot. HPM systems offer another edge since they can disable the electronics of multiple targets simultaneously, ideal for defeating drone swarms or incoming precision-guided munitions. Particle beams remain largely experimental, with no near-term deployments anticipated.

Lasers can strike targets with pinpoint accuracy, generating almost no collateral damage and at costs as low as a few euros per shot.

Critically, DEWs align well with the demands of the age of mass precision: the ability to achieve the effects of massed forces or firepower through precise, coordinated, and often distributed means. In this context, the ability to engage a high volume of targets at low cost becomes a cornerstone of defence and deterrence.

The strategic advantage of directed energy weapons stems from their capability to reverse or eliminate the cost imbalance which characterises contemporary air defence situations. The affordability of small drones and loitering munitions has allowed adversaries to create economic challenges for defenders who must use a finite number of expensive missile interceptors.

In 2025, a €1,000 drone can force the launch of a €3-million Patriot missile which leads to an unsustainable equation. DEWs shift this balance. With operating costs as low as €1 to €10 per laser shot or even less per microwave pulse, defenders can neutralise threats at a cost lower than that of the attacking platform. This reestablishes cost symmetry, deterring massed attacks by making them far less feasible and allowing defenders to operate effectively without exhausting munitions stockpiles.[2]

In 2025, a €1,000 drone can force the launch of a €3-million Patriot missile which leads to an unsustainable equation.

STATE OF PLAY: EUROPE

European Defence Programmes and Applications

Several European states are actively investing in DEWs for air and missile defence. The EU's Tactical Advanced Laser Optical Systems (TALOS) Two programme, led by the French firm Cilas, aims to produce a 100-kW-class laser by 2030, building an indigenous European supply chain of beam-combining and wavelength-tuneable laser technologies.[3] France's HELMA-P laser system is already deployed on some French Navy vessels and a number were deployed to defend Paris during the 2024 Summer Olympics.[4] A handheld version is also under development by Cilas.

Germany plays a leading role in the integration of lasers at sea. In 2023, the German Navy conducted over 100 live firings from a high-energy laser (HEL) demonstrator installed on the frigate *Sachsen*.[5] This laser, developed by Rheinmetall and MBDA Deutschland, has successfully destroyed test drones and will be fielded later this decade.

In the United Kingdom, the DragonFire programme, a £100-million joint project by MBDA, Leonardo UK and QinetiQ has demonstrated laser weapons capable of burning through aerial targets with extreme precision. In 2023, DragonFire successfully destroyed drones in adverse weather conditions and proved accurate at distances beyond one kilometre.[6]

The UK continues to develop its laser capabilities while simultaneously working on high-powered microwave weapons technology. The Royal Navy plans to deploy Dragonfire systems on its ships starting in 2027 while the Royal Air Force investigates integration on aircraft. The UK MOD has also tested a RapidDestroyer prototype system which uses electromagnetic energy to neutralise drone swarms in mid-air.[7] The mobile RapidDestroyer, fitted into a van-sized device, sends electromagnetic bursts to disable numerous drones simultaneously. It complements other UK systems like DragonFire by offering rapid, wide-area effects ideal for protecting critical infrastructure and forward-deployed units.

In 2024, a consortium of Leonardo UK, Thales UK and the UK MOD tested its new airborne Miysis DIRCM laser which defeated 100% of infrared-seeking missiles in live fire by "dazzling" their seeker heads.[8] This self-protection system for transport and surveillance aircraft is currently being deployed throughout Europe.

Italy has also entered the DEW arena. In December 2024, MBDA Italia and Leonardo signed a Memorandum of Understanding to co-develop naval laser systems tailored for drone defence. Two variants are planned: a lighter version suitable for retrofitting existing naval platforms, and a high-powered system for new-generation warships.[9] Leonardo is focusing on beam direction and targeting, while MBDA provides the laser generation. These systems support Italy's naval defence modernisation efforts and its development of autonomous air defence systems.

In 2025, Ukraine revealed its new Tryzub anti-drone laser which disrupts first-person view drones at altitudes of up to two kilometres and has even proven capable of attacking ground targets, demonstrating both kinetic and non-kinetic capabilities.[10]

Looking further to the future, DEWs could someday be deployed on high-altitude platforms or aircraft for intercepting ballistic missiles. However such particle beam systems remain decades away from feasibility due to size, power and integration challenges.

DEWs support the distributed operations model that is foundational to mass precision warfare.[11] The distributed operations model uses networked precision-guided systems spread across the battlefield to deliver fires while evading detection and improving survivability. Low-cost DEWs deployed on mobile platforms and at critical sites can help provide protection against enemy mass precision fires.

While current European DEW programmes are focused on air, land and maritime defence, there is increasing interest in space-based threats. The EU's 2023 Space Strategy for Security and Defence highlighted the risks posed by directed energy to satellites. PESCO's Defence of Space Assets (DOSA) initiative is specifically responsible for developing capabilities to counter space-based DEW threats through satellite hardening, rapid replacement and EU-wide Space Situational Awareness networks (EU-SST). The French technology demonstrator, which is designed to target other satellites, could be a major step forward for European space-based directed energy capabilities.

STATE OF PLAY: REST OF THE WORLD

The development of directed energy technology continues to progress in the United States, Canada, Japan, South Korea, Türkiye and Australia. The development of DEW programmes receives substantial strategic funding from multiple countries across North America, Asia and the Pacific region. The development of

these programmes stems from increasing drone threats, the requirement for distributed defence capabilities, and the need for cost-effective scalable tools for deterrence.

The development of DEW programmes stems from increasing drone threats, the requirement for distributed defence capabilities, and the need for cost-effective scalable tools for deterrence.

The United States has fielded a 300-kW laser system under the Army's IFPC-HEL programme. Built by Lockheed Martin, the system is undergoing field testing and may be deployed to protect US bases by 2026.[12] The US Navy has also deployed HELIOS, a 60-kW laser system that can disrupt targeting systems and destroy incoming drones or missiles, on the USS Preble after validating naval laser defence concepts in 2024.[13]

Additionally, the Epirus Inc. Leonidas HPM system has demonstrated its ability to disable drone swarms and is already deployed in the Middle East for real-world operational testing. The US Air Force's THOR and Mjolnir microwave systems further illustrate America's broad DEW portfolio aimed at base and critical infrastructure defence.[14] Furthermore, the US Space Force is also exploring directed energy systems for use in space.[15]

At the 2025 Sea-Air-Space exposition, General Atomics unveiled a laser-equipped MQ-9B drone featuring a scalable 25-kilowatt directed energy system. This development signals a major step in the US effort to integrate airborne DEWs for rapid, precision engagement against drone swarms and other threats.[16]

Canada became the fifth NATO country to test above-the-horizon laser systems during the 2024 IDEaS CUAS Sandbox in Alberta. The Canadian government has allocated over $350 million to DEW and adjacent defence technologies, demonstrating their intent to integrate non-kinetic systems into its Counter Uncrewed Aerial Systems (counter-UAS) strategy.[17]

Japan's Ground Self-Defense Force recently introduced a 10-kW-class laser truck to counter drones and low-flying missiles. Japanese firms like Mitsubishi and Kawasaki have also unveiled their own anti-drone laser weapons while Tokyo is partnering with Washington to develop microwave systems for base protection.[18] In 2024, South Korea deployed its Block-I laser system, developed by Hanwha Aerospace, which can engage targets at a cost of just $1.40 per engagement.[19] Seoul has also deployed the "Skylight" (Cheongwang) system across its capital and frontline areas to defend against North Korean drone threats.[20]

Türkiye is also active in DEW development. Roketsan's ALKA system, a combined electromagnetic and laser DEW, was credited with neutralising a Chinese Wing Loong II drone in Libya in 2019. This marked one of the earliest battlefield uses of this technology.[21] Another development, Aselan's GÖKBERK system integrates laser hard-kill and soft-kill jamming functions. Türkiye plans to deploy these systems as part of its 'Steel Dome' layered air defence project. Moreover, Türkiye's TF-2000-class destroyers are also planned to have DEW capabilities as part of its future naval forces.[22]

Australia has made notable progress through public-private collaboration. AIM Defence's Fractl and Fractl:2 portable laser systems have been acquired by the Australian Defence Force. These systems are capable of neutralising drones up to 100 km/h and can down as many as 50 drones on a single charge.[23] Australia's Thales division and the University of Adelaide are also researching ultra-short pulse laser systems for long-range anti-drone and counter-swarm defence.[24]

China has demonstrated notable advances in directed energy weapons (DEWs), particularly through the development of high-power microwave systems designed to neutralise drone swarms and laser systems deployed on naval vessels.[25] At the 2024 Zhuhai Airshow, China revealed new vehicle-mounted HPM platforms and Chinese researchers have reported breakthroughs in laser cooling technology that could enable sustained high-energy operations.[26] Additionally, China is believed to be advancing ground-based anti-satellite laser capabilities, signalling a strategic focus on counter-space operations.[27]

Russia has developed the Peresvet laser system for use by its Strategic Missile Forces for anti-satellite and air defence roles.[28] There are also unverified claims that Russia has used tactical lasers to disable drones in Ukraine. However, these systems remain shrouded in secrecy and Russia has yet to publicly demonstrate a high-powered laser or microwave system at the scale or technological maturity of its NATO counterparts.[29]

While both China and Russia are advancing DEWs as part of broader military modernisation, China is considered behind the United States in the development and deployment of directed energy weapons, and slightly behind or roughly on par with leading European countries (depending on the application). Russia also appears to be behind both Europe and the US in terms of operational deployment.

INDUSTRIAL LEADERSHIP AND TRANSATLANTIC COOPERATION

Europe's defence industry has taken a leading role in DEW development, often in cooperation with US firms. MBDA, Europe's multinational missile consortium, has taken central roles in the DragonFire, TALOS, and German naval HEL programmes. CILAS, a French laser company partly owned by MBDA, is advancing compact and mobile DEWs. Thales, Leonardo, Rheinmetall and QinetiQ also contribute specialised components.

On the US side, Lockheed Martin, Raytheon Technologies and Epirus dominate the high-power segment. Epirus's Leonidas microwave system has demonstrated reliable counter-swarm performance and is already being evaluated for forward deployment.

Transatlantic cooperation ensures that NATO's defence posture benefits from shared advances, common standards and battlefield interoperability provided this collaboration remains stable in the coming years.

THE FUTURE DIRECTED ENERGY LANDSCAPE

DEWs are central to Europe's air defences in an era of mass precision. Across Europe and the world, military planners are integrating lasers and microwaves into next-generation defences against drones, missiles and asymmetric threats. With successful trials, increasing budgets and industrial momentum, DEWs are on track to become standard tools in Europe's defence architecture.

Globally, the United States remains the clear leader in DEW development and deployment. It is the only country currently fielding operational systems above 300 kW, has deployed DEWs on naval destroyers, and is leading in both high-energy lasers and high-power microwave technologies. Meanwhile, Europe is closing the gap with sophisticated national and multinational programmes. Countries like France, the UK, Germany and Italy are making substantial progress in scalable systems, particularly for naval and drone defence applications. Elsewhere, countries such as Japan, South Korea, Australia and Türkiye are advancing rapidly with compact, affordable DEWs tailored to their regional security environments.

Critically, these systems support distributed operations, enable defence against precision fires at scale, and reinforce Europe's autonomy at a time of growing US strategic uncertainty. If Europe continues to invest wisely, DEWs can help ensure it will be ready to deter Russian aggression and win the wars of the future.

Finally, as strategic competition extends beyond air, land and sea into the space domain, DEWs may also be poised to become critical tools for protecting vital orbital assets. China, Russia, France and the US are all developing or testing ground and space-based lasers capable of disabling or damaging satellites. The absence of international norms around DEWs in space increases the risk of escalation and miscalculation. For Europe and its allies, integrating space resilience into DEW development strategies through satellite hardening, redundancy and responsible innovation, will be essential for credible deterrence and strategic stability in this new domain.

RECOMMENDATIONS FOR EUROPE

1) Sustain and increase investment in DEW research, development and production through the European Defence Fund and European Sky Shield Initiative to develop capabilities and cost-effective defences against mass precision threats.

2) Integrate DEWs into NATO defence doctrine and layered air-and-missile defence systems as standard tools, complementing traditional interceptors to counter drones, rockets and loitering munitions at low cost. Over time, the shift of spending on DEWs versus ballistic interceptors will require careful coordination to ensure no strategic gaps in coverage.

3) Strengthen European and transatlantic cooperation in DEW development by aligning national programmes such as MBDA-led joint projects, sharing technology and establishing common standards for interoperability across NATO.

4) Fast-track deployment of proven DEW systems (such as ship-mounted lasers and mobile anti-drone HPM units) to protect critical infrastructure and forces from drones and rockets, while scaling up to higher-power systems for missile defence as the technology matures.

5) Incorporate space resilience into Europe's DEW strategy by hardening satellites, building redundant space systems, and expanding space situational awareness networks to deter or withstand directed-energy attacks on orbital assets.

The support the European Policy Centre receives for its ongoing operations, or specifically for its publications, does not constitute an endorsement of their contents, which reflect the views of the authors only. Supporters and partners cannot be held responsible for any use that may be made of the information contained therein.

1 Kremidas-Courtney, C. (2025, March 31). *How to spend it: European defence for the age of mass precision*. European Policy Centre.

2 Black, J. (2025, March 6). *David vs. Goliath: Cost asymmetry in warfare*. RAND Corporation

3 Pluta, W. (2025, March 4). *Europe develops laser weapons*. heise online.

4 Ministère des Armées. *HELMA-P: A laser beam to neutralize rogue drones*.

5 MBDA. (2023, September 22). *Bundeswehr successfully concludes laser weapon trials at sea*. MBDA.

6 Chuter, A. (2024, January 19). *In first, UK downs aerial drone with test shot from DragonFire laser*.

7 *UK tests microwave weapon to disable drone swarms*. (2025, April 16). *Financial Times*.

8 Leonardo S.p.A. (2025, May 23). *Miysis DIRCM*. Leonardo.

9 Bisht, I. S. (2024, December 13). *MBDA, Leonardo to develop laser-based counter-drone system*. The Defense Post.

10 Bisht, I. S. (2025, April 15). *Ukraine unveils laser weapon that can down cruise, ballistic missiles*. The Defense Post.

11 European Policy Centre (2025, April 2). *The Language of Power: How Europe should spend its extra defence budgets* [Audio podcast].

12 Lockheed Martin. (2023, October 10). *US Army selects Lockheed Martin to deliver 300 kW-class solid-state laser weapon system*.

13 Ceder, R. (2025, February 4). *US Navy hits drone with HELIOS laser in successful test*. Navy Times.

14 Rogers, N. (2023, May 16). *AFRL conducts swarm technology demonstration*. Air Force Research Laboratory.

15 Strout, N. (2021, June 16). *The Space Force wants to use directed-energy systems for space superiority*. C4ISRNET.

16 Bisht, I. S. (2025, April 17). *General Atomics displays MQ-9B armed with laser weapon*. The Defense Post.

17 Ken Research. (2025. *Global Directed Energy Weapon (DEW) Market*.

18 Majumdar, O. (2025, May 21). *DSEI Japan 2025: Japan's army tests laser system*. Janes.

19 Business Insider. (2024, July 13). *South Korea plans to roll out 'Star Wars' laser weapon to melt North Korean drones for just $1.50 a hit*. Business Insider.

20 Unmanned Airspace. (2024, October 4). *South Korea commissions Cheongwang high-energy laser for military use*. Unmanned Airspace.

21 Husain, A. (2022, June 30). *Turkey builds a hyperwar capable military*. Forbes.

22 Helou, A. (2025, March 10). *Turkey's Aselsan tests laser counter-drone system, part of Steel Dome project*. Breaking Defense.

23 Oderberg, I. (2024, March 25). *Australian military buys $5m laser-based anti-drone system*. The Guardian.

24 Overell, J. (2024, November 22). *Thales Australia and University of Adelaide partner to explore long-range laser C-UAS technology*. C-UAS Hub.

25 Hurst, C. (2025, February 15). *China unveils new high-power microwave weapon systems*. Foreign Military Studies Office.

26 Saballa, J. (2023, August 14). *China claims 'huge breakthrough' in laser weapon development*. The Defense Post.

27 Honrada, G. (2023, May 3). *China's Korla site laser-focused on US spy satellites*. Asia Times.

28 Defense Express. (2024, August 12). *Peresvet Laser System is to Blind Reconnaissance Satellites and Cover ICBMs, Specifications Revealed by Russia*.

29 Newsweek. (2022, May 18). *Russia using powerful laser weapons against Ukraine*. Newsweek.

With the strategic support of King Baudouin Foundation
Working together for a better society

Co-funded by the European Union