EXPLAINER

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Light speed weapons?

Directed energy and the future of the ADF

Summary

- Directed energy weapons (DEW), including high energy laser and high-power microwave weapons, are increasingly important in counter-drone tasks across air, sea and land.
- Technical challenges remain in optimising DEW technology as a viable military capability but DEW capabilities have the potential to create an inflection point in warfare as they offer virtually instantaneous effects at very low cost per shot compared with traditional missiles and, with a stable power source, they have effectively unlimited 'magazines'.
- US Operation Epic Fury and Israel's Operation Roaring Lion show the need to invest in cheaper and more sustainable DEW capabilities which may not replace but will reduce reliance on expensive missile defence interceptors such as Patriot.
- Future space-based segments, including the US Golden Dome missile system, could exploit a greatly expanded range for DEW, given the abundant availability of solar power in space.
- China should be viewed as a competitive adversary in this field with its DEW capabilities maturing at speed, having unveiled a 20-gigawatt power source for a microwave weapon designed to attack low-earth orbit satellites, including Starlink satellites.
- While DEW potentially offers revolutionary transformation to counter missile and drone threats, they are not a complete alternative to traditional military capabilities including advanced missile systems, with the most effective defence strategy requiring both traditional and modern capabilities.
- Australia should develop a DEW strategy as part of its defence policy to grow industrial capacity and update integrated air and missile defence and counter-drone capabilities.
- Australia should accelerate development of this emerging capability by pursuing DEW with key allies and partners, including through AUKUS Pillar II.

Introduction

In early March, large numbers of unidentified drones swarmed Barksdale Air Force Base in Louisiana, that is home to nuclear-capable B-52H bombers.[1] In the same way that the Ukrainian military destroyed Russian bombers using drone attacks in 2025's Operation Spider's Web, had these drones been armed, a significant portion of the airborne leg of the US nuclear triad could have been at risk.[2] The lack of a counter to the drone threat in both instances highlights the importance of effective C-UAS technologies, of which DEW are a critical element. For Australia, which depends on a network of northern bases to support a strategy of deterrence by denial, there is a clear need for investment into the development of DEW – specifically high-energy laser (HEL) and high-power microwave (HPM) weapons – to ensure greater resilience in the face of threats such as armed drones, and eventually, more advanced missile systems. This explainer considers the nature of DEW and the opportunities and risks they could present for the Australian Defence Force; the current work on DEW systems for C-UAS; and how DEW might be employed. It also makes the case for Defence to develop a DEW strategy that incorporates collaborative development under AUKUS Pillar II.

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Deploying DEW – an approaching inflection point in future warfare

As of late March 2026, there is no formal confirmation that either HEL or HPM weapons have been operationally employed in the conflict in Iran. Israel's Iron Beam HEL system, which was reportedly employed against Hezbollah rockets in 2025, is available for deployment.[3] However, reports of its use during the current war are conflicting. Video circulating on social media alleging use of Iron Beam has been challenged by the Israeli Defence Force.[4]

The US Navy has deployed a HEL system – known as the 'High Energy Laser with Integrated Optical-dazzler and Surveillance', or 'HELIOS' – onboard an Arleigh Burke-class destroyer, USS *Preble*, but informed sources indicate the vessel has not yet been deployed to US Central Command.[5] HELIOS is designed to intercept combat drones, aircraft and missiles. Other systems, such as the Optical Dazzling Interdictor, Navy (ODIN), are designed to dazzle rather than destroy. ODIN is fitted to USS *Spruance*, an Arleigh Burke-class destroyer involved in Operation Epic Fury, but the US Navy has yet to confirm any combat use of the system.[6]

However, the absence of confirmed DEW use in the current Iran war does not diminish their potential application against the growing challenge of low-cost armed drones. DEW offer a more sustainable alternative and reduced reliance on expensive missile defence interceptors such as Patriot, a gap now evident in the US's Operation Epic Fury and Israel's Operation Roaring Lion.

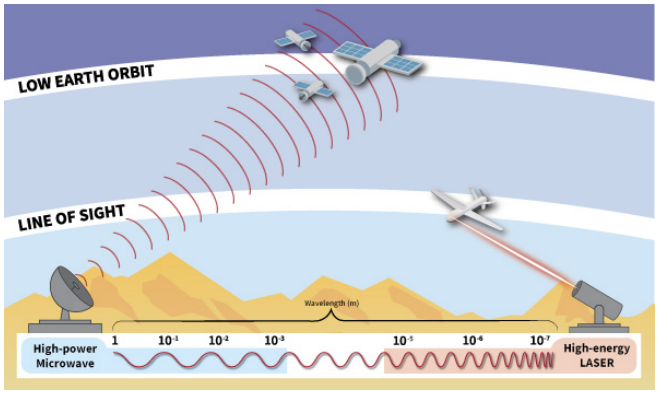
For Australia, in considering integrated air and missile defence (IAMD) and counter-drone capabilities, there is a clear need to invest in DEW technologies for introduction into the ADF to meet growing drone-based threats.

Opportunities and challenges of DEW

DEW offer several tactical advantages over traditional weapons. They produce destructive or disruptive effects across the electromagnetic spectrum, from radio frequencies to visible light. DEW can generate effects at the speed of light – close to 300,000 km/sec – producing almost instantaneous results. With a stable power source, DEW have effectively unlimited 'magazines'. This allows for repeated attacks on a target to destroy or damage it, or rapid engagement on multiple targets simply by redirecting the beam. Whilst DEW are a 'line of sight' weapon, their cost per kill is very low relative to a traditional defensive missile: it costs cents or, at most, a few dollars per shot, compared with up to $US 4 million for advanced air defence missiles, such as the Patriot interceptor missile. As DEW technology matures, the cost balance will decisively shift in favour of defensive systems based on DEW rather than missile-based capability systems.[7] Certain types of DEW, particularly high-power radio frequency or microwave weapons, also enable scalable and reversible soft-kill effects to disable or deny rather than destroy.

Adversary DEW capabilities are maturing at speed. China has unveiled a 20-gigawatt power source for a microwave weapon designed to attack low-earth orbit satellites, including Starlink satellites.[8] During its 2025 Victory Day parade in Beijing, it also displayed a 30-kilowatt road-mobile laser for C-UAS roles, as well as a LY-1 laser optimised for defending naval vessels against incoming missiles. Beijing clearly recognises that DEW provide a radically different approach to military operations through exploitation of new military technologies for greater flexibility in complex battlespaces.

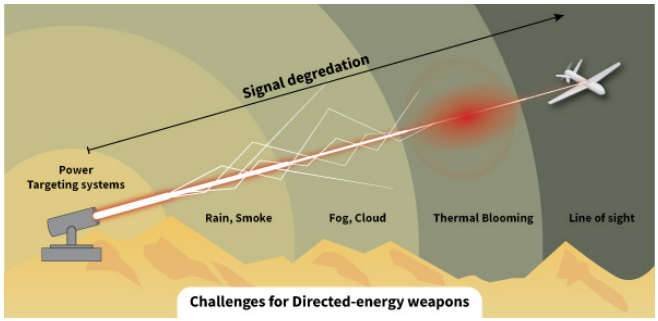
Figure 1: The difference between High Power Microwave and High Energy Laser weapons



Source: Byron Illyes, ASPI

Technical challenges remain in optimising DEW technology as a viable military capability. These should not be ignored.[9] Generating sufficient power in the field to sustain DEW is not a trivial problem, nor is developing the technical means to keep a beam accurately on target. The nature of DEW means they are limited to short-range engagements within line of sight and are unable to strike a target over a visible horizon. DEW technology is also sensitive to atmospheric conditions. Even clear air weakens laser beams over distance, while smoke, rain, fog, clouds and other atmospheric or artificial obstructions can further interfere with DEW effectiveness. Laser weapons face additional challenges from the effects of beam diffraction, scattering, as well as thermal blooming, in which beam energy superheats the atmosphere and weakens a beam's effectiveness. However, future space-based segments – for example, for use in the US Golden Dome missile defence system – could exploit a dramatically expanded range for DEW, given the abundant availability of solar power in space and the absence of the environmental challenges.[10]

Figure 2: Technical and environmental challenges for High Energy Laser weapons



Source: Byron Illyes, ASPI

Current DEW development in Australia

The 2024 National Defence Strategy (NDS) and Integrated Investment Program (IIP) make only limited reference to DEW technology as a future capability for the ADF.[11] Both documents identify 'directed energy' as one of six defence innovation, science and technology priorities alongside hypersonics, trusted autonomy, quantum technology, information warfare and long-range fires. However, the IIP does not identify a specific DEW program. Instead, it highlights investment in counter-small uncrewed aerial systems, including capabilities being pursued under an initiative known as Project Land 156.[12] This suggests that Defence recognises the potential of directed energy as an emerging enabler rather than a near-term capability.

Government statements have been vague regarding the role of DEW in Land 156. This is a A$1.3 billion, decade-long effort to ensure the ADF remains at the forefront of counter-drone capability. Within this program, the Advanced Strategic Capabilities Accelerator is also undertaking Mission Syracuse, aimed at developing C-UAS capabilities as part of a layered and distributed system. For the moment, Land 156 is focused on hard-kill C-UAS capabilities rather than DEW-based systems. However, additional sensor and effector systems may be integrated over time, representing an opportunity to bring DEW technology into Land 156. With the war in Iran now demonstrating cost-inefficiencies of using multi-million-dollar Patriot missiles to shoot down $20,000 Shahed Drones, the case for DEW is clear.

Investment into a HEL weapon for the C-UAS role is an obvious step. For example, an Australian developed HEL, called 'Apollo', is designed to 'disable more than 20 UAS per minute', generating varied effects out to 15 km for optical sensor denial or 3 km for destroying a target. It can fire continuously using external power and more than 200 shots using internal power.'[13]

Other Australian companies are developing portable drone guns. These use high-powered radio frequency effects to disrupt the command and control of drones, as well as interfering with global navigation satellite systems that provide positioning, navigation and timing support to adversary drones. The same technology can be scaled up to provide an all-in-one C-UAS detection, tracking and disruption capability by using radio frequency, radar and optical technologies.[14] Integrating DEW with kinetic systems and sensor networks offers a clear path forward for Land 156.

How might the ADF employ DEW in the future?

Attacks by Iranian drones in the Middle East and Russian drones in Ukraine highlight the threat these systems pose. Relying on expensive missile-based defensive systems where high costs deny deep magazines – such as those upon which the US relies – could see ADF units quickly overwhelmed as interceptor missile stockpiles run out. This doesn't diminish the need for traditional IAMD to counter longer-range ballistic and cruise missile threats. Furthermore, DEW remains a defensive technology, and traditional offensive military systems, including long-range missiles, will remain essential. However, investment into IAMD and long-range strike should be complemented by sovereign development of DEW systems to counter the growing drone challenge.

The importance of maritime capability to Australia's NDS should reinforce the need to develop DEW in a manner that enhances the survivability of Australian naval surface vessels – representing 16 percent of capability investment under the current IIP – by strengthening fleet air defence at sea, particularly close-in defence. The Royal Navy is testing its DragonFire HEL weapon for this purpose and it will enter service in 2027, five years sooner than originally planned.[15] When considering future upgrades to existing naval surface combatants such as the Hobart-class air warfare destroyers, the Royal Australian Navy should prioritise integrating DEW-based C-UAS.

As DEW technology matures and overcomes current technical challenges, it could offer the RAN a means to counter not just drones but also antiship missile threats. Modern warships face challenges in countering missile and drone threats. A 2023 US Congressional Research Service report notes that, they face limited magazine depth (i.e. the number of vertical launch system [VLS] cells available on a ship) and cannot reload traditional weapons in VLS cells at sea.[16] Once perfected, DEW could help ease these challenges by reducing dependency on missile-based defensive systems.

Government statements have been vague regarding the role of DEW in Land 156

The threat posed by swarming autonomous systems and more sophisticated ballistic and cruise missiles demands layered IAMD ashore. This is an essential capability requirement for the ADF and a growing capability gap – one that was highlighted as far back as the 2023 DSR but is yet to be decisively closed. An ability to counter adversary drone swarms through C-UAS technologies (which should include DEW) will also be crucial for defending fixed military facilities, such as air and naval bases and rear-area logistics sites.[17]

With the Australian Army undertaking littoral operations, ground forces deployed ashore must also be defended from drone threats. Ukrainian forces are currently seeking to do so using HELs. As the army employs laser weapons to counter UAS, they could also use high-powered radio frequency systems to counter the threat posed by improved explosive devices. There is a need for both electronic warfare to jam threats and DEW capabilities to counter threats such as drones, incoming rockets, missiles and artillery shells at longer ranges.

Where we need to be heading: towards a DEW strategy for the ADF

Acquisition and development of DEW need to be aligned with ADF capability and operational requirements. An Australian DEW strategy would provide a framework to accelerate the development of this technology in line with Defence requirements and ensure timely integration into the force structure. It should also strengthen the Australian defence industry's ability to support sovereign DEW capabilities and emphasise continuous modernisation, as with UAS, to ensure that the ADF and defence industry remain at the cutting edge of DEW development.

The strategy should also incorporate a policy that emphasises building opportunities for collaboration on DEW potentially under AUKUS Pillar II or with partners such as Japan and South Korea. In this way, even as Australia pursues sovereign capability development in a manner that is independent and faster, it can also tap into collaborative opportunities when necessary. Such a strategy should highlight the opportunity for Australia to lead in the development and testing of DEW, considering its natural geographical advantages and technology-driven economy.

Conclusion

DEW are an emerging technology of the modern battlefield, offering a fundamentally different means to defend critical military capabilities. By engaging targets at the speed of light and at comparatively low cost per shot, DEW could provide the ADF with a highly responsive approach to countering armed drones and, over time, advanced missile threats, particularly against ADF naval surface combatants. The challenge posed by these types of threat is very clear in current operations, including Operation Epic Fury against Iran, and in the war in Ukraine. Also, China's development of DEW is moving rapidly, and could threaten even US and allied satellites in orbit. Some technical challenges associated with development of DEW remain, and they aren't a complete alternative to traditional military capabilities, but they enhance resilience in the face of adversary drone and missile threats. The next step should be for Australia to develop a DEW strategy, which sees these capabilities move from research to operational deployment, and integrates DEW technology through an ADF continuous modernisation process. This can also help build sovereign industrial capacity for DEW alongside allies and partners.

Figure 3: USS Portland tests High Energy Laser Weapon system in Gulf of Aden, 15 December 2021.

Source: US Navy Photo, online.

Notes

1 Howard Altman, 'U.S. Battled Drone Incursions over Key Bases at Home After the Launch of Epic Fury', *The War Zone*, March 24th 2026, online.

2 Kateryna Bondar, 'How Ukraine's Operation "Spider's Web" Redefines Asymmetric Warfare', CSIS, June 2nd 2025, online.

3 Thomas Newdick, 'Israel's Iron Beam Laser Air Defense System has downed enemy drones', *The War Zone*, May 29th 2025, online.

4 Yuval Azulay, 'Iron Beam remains unused despite renewed drone threat from Iran and Lebanon', CTECH, 8th March 2023, online; Assaf Gilead 'What happened to Iron Beam?', Globes, 11th March 2026, online.

5 Ian Ellis Joines, 'Operation Epic Fury: The First Ten Days', online.

6 Naval News, 'U.S. Navy Destroyer Deploys ODIN Laser Directed Energy Weapon System during Operation Epic Fury', 2nd March 2026, online.

7 United States Government Accountability Office (GAO), 'Directed Energy Weapons – DOD Should Focus on Transition Planning', April 2023, p.5, online.

8 Stephen Chen, 'Chinese scientists build world-first 20GW microwave weapon that can fire 60 second bursts', South China Morning Post, 5th February 2026, online.

9 Michael Spencer, 'Directed Energy Weapons – Playing with Quantum Fire', Air Power Development Centre, 2020, pp. 43-46, online.

10 Steve Trimble, 'Pentagon's Megawatt Laser Demo to Highlight Recent Tech Breakthroughs', *Aviation Week and Space Technology*, March 16th 2026, online.

11 Department of Defence, National Defence Strategy, 2024, 9.4, p. 63; Integrated Investment Program, 'Innovation, Science and Technology', 2024, p.18.

12 Department of Defence, 'Albanese Government ramps up investment in counter-drone capabilities for ADF', online.

13 EOS Australia, 'Apollo High Energy Laser Weapon', online.

14 Droneshield, 'DroneSentry-X Mk 2', online.

15 Ministry of Defence UK, 'Boost for Armed Forces as new laser weapon takes down high speed drones', 20th November 2025, online.

16 Ronald O'Rourke, 'Navy Shipboard Lasers: Background and Issues for Congress', Congressional Research Service, December 20th2023, online.

17 Timothy Millar, 'Not just drones, but massed swarms of them. Defences can't cope', *The Strategist*, 1st July 2025, online.

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Explainers: Are short analyses that raise awareness of both existing and emerging security and defence policy challenges facing Australia and the region.

Cover image: Dragonfire laser system test firing/wikipedia.

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