

# Directed energy weapons

Directed energy weapons (DEWs) use concentrated energy from electromagnetic or particle technology, rather than kinetic energy, to degrade or destroy targets. DEWs have the capability to damage physical targets over several kilometers with high precision and accuracy. As the technology advances, weaponized directed energy (DE) systems are becoming more powerful, prevalent, and increasingly integrated into air, land and sea platforms.



## Enabling Science and Technology

### High energy lasers

High Energy Lasers (HELs) have significant advantages over conventional munitions, such as the ability to engage targets at the speed of light with pinpoint accuracy and a virtually unlimited magazine. However, they can be adversely affected by atmospheric conditions like rain or fog.

### High power microwaves

High power microwave weapons (HPMs) have a shorter range than HELs and their beam degrades over long distances, but they are not affected by weather and can impact targets over a wide area.

### Millimeter waves

Millimeter wave directed energy has various non-lethal military applications, including crowd control and area denial. Although proven to be very safe, millimeter wave energy has the capability to produce significant injuries.

### Particle beams

Particle beam weapons have strong penetration ability, high speed, high energy and can operate in all weather conditions. However, the technology is extremely complex with many challenges to overcome before it can be used in combat.

### Space

Directed energy applications in space are the focus of much research, including using DE for propelling spacecraft, intercepting satellites or deflecting comets or asteroids threatening earth.

**“The weapons have potential to be game-changers in the near future and revolutionary in the long term. They could provide a number of capabilities and advantages over traditional weapons because of their speed-of-light delivery, precision engagement, controlled/scalable effects, logistical benefits and low cost per shot.”**

Nurettin Sevi, GlobalData, National Defense Industrial Association Magazine. [Uptick in Spending Seen for Directed Energy Weapons](#), October 13, 2020.

## Signals

### Academic



An analysis of the recent literature shows that 4 of the top 5 affiliations by publication output are from the USA. The US Air Force Research Laboratory (AFRL) is the leading organization overall, followed by the University of California and the University of Maryland.

### Government



Compared to China, USA-based affiliations have proportionally more interest in challenges such as atmospheric effects and thermal management. China's focus is on high power microwave technologies and unmanned aerial vehicles.

### Collaboration



Research collaboration is mainly among organizations in the same country. The University of California has the most research partners, followed by the US Air Force Institute of Technology and the US AFRL.

### Defence



Diode lasers are emerging as an important directed energy technology due to characteristics such as scalability, efficiency, resilience to high temperatures and good beam quality.

### Corporate



Large, multi-national defence contractors like Raytheon, Boeing and BAE Systems are the global leaders in patents on directed energy weapon technologies.

**“The proliferation of small, low-cost Unmanned Aircraft Systems (UAS) on the battlefield requires a layered defense that includes low-cost directed energy. The deep magazines of laser weapon systems are ideally suited to counter swarms of hostile UAS.”**

[DARPA MELT program description](#), January, 2022.

## Impact



### Social

Low-power lasers are already being used on people for crowd control, protest suppression and deterring pirates. Scientific literature shows that a DEW is suspected to be the cause of the “Havana syndrome” reported by US diplomatic personnel in Cuba.



### Policy

Potential effects of DEWs like burning skin, eye damage or radiation sickness may raise concerns under international humanitarian law, which prohibits inflicting superfluous injury or unnecessary suffering to combatants.



### Economic

More than 30 countries have DEWs and investment is increasing rapidly. The USA alone has more than doubled its spending on DEW research since 2017.



### Environmental

Some DEW lasers are fueled by a toxic cocktail of environmentally-damaging chemicals which require special handling. As a result, electrically powered systems are now preferred.



### Defence

Compared to traditional munitions, DEWs have a lower cost per shot. The theoretically unlimited magazine could also reduce the total system lifetime cost by means of reduced logistical demands.

**“DE military capabilities have reached or passed a tipping point in their criticality to the successful execution of cross domain military operations by the US, Allies, and current and potential rivals and adversaries.”**

Chief Scientist for Directed Energy, US Air Force Research Laboratory. [Directed Energy Futures 2060](#), 2021.

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