INNOVATION HIGHLIGHT

Technology in Support of National Security

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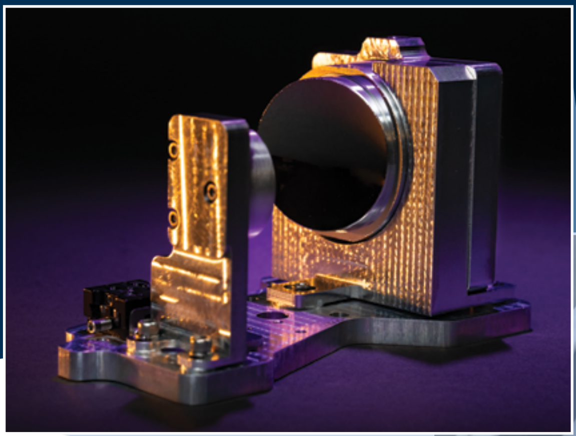
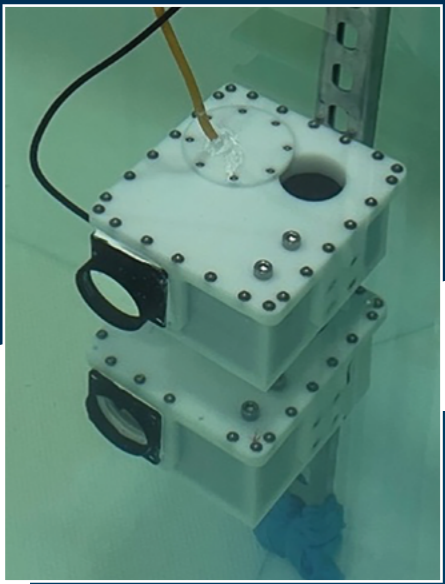
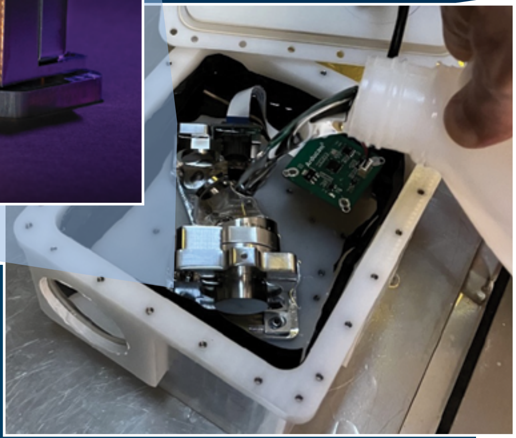
Freeform-Optics-Enabled Underwater Camera



Center, the prototype two-mirror freeform optical design, fabricated via diamond turning, provides a wide field of view and a large aperture.





At left, encased in their oil-filled containers are two cameras submerged in the test tank. At right, the optical system is filled with oil to render it insensitive to extreme deep-sea pressure.

Lincoln Laboratory researchers designed an all-reflective optical system that utilizes two complex mirrors instead of a traditional lens composed of eight glass elements. They implemented this revolutionary freeform optics design in a camera installed in a container filled with an incompressible fluid, like mineral or silicone oil, to allow operation in high-pressure, deep-sea environments. Immersion in the fluid does not inhibit the optical performance of the mirrors, making this novel camera an alternative to underwater systems encased in costly pressure-resistant packaging. This camera in either a fixed location or on a vehicle can enable underwater inspections or observations of fish populations and ocean health.

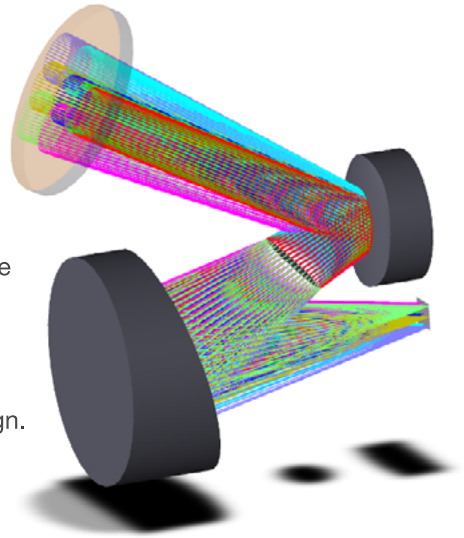
KEY FEATURES

- A 20-degree diagonal full field of view, a tenfold improvement over conventional optics
- Diffraction-limited system, enabling highest-resolution imaging
- Achromatic capability, allowing imaging in light ranging from ultraviolet to longwave infrared
- Telecentric and unobscured aperture, resistant to biofouling
- Potential to scale for a variety of applications and for low-cost, epoxy-molded mass production

LINCOLN LABORATORY
Massachusetts Institute of Technology

Innovative Solution

Lincoln Laboratory's novel two-mirror, freeform optics design expands the capabilities of optical systems, while offering performance that cannot be beat by conventional glass-based optics. The pressure-tolerant, lightweight underwater camera system is an example solution enabled by this design. Recognizing that submersion in an incompressible liquid or fluid like mineral oil does not interfere with the focusing power of reflective mirrors, engineers encased the optical unit in a fluid-filled container that enables the camera to resist the crushing pressure at extreme ocean depths. This container eliminates a need for a costly, cumbersome "strong box" to protect an underwater camera from pressure-induced damage and thus opens opportunities for monitoring the health of undersea structures and the ocean environment.

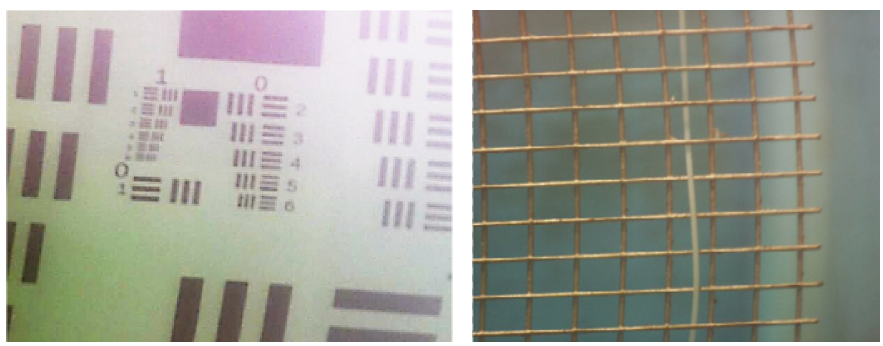


The drawing illustrates the two-mirror, diffraction-limited freeform optical design.

Potential of Freeform Optics

This design could be adapted for applications that demand an optical system able to withstand extreme conditions of pressure or radiation—for example, conducting space surveillance, imaging from airborne platforms, and monitoring land in harsh climates.

This outdoor photograph of the radar illustrates that a camera using the freeform optics design can create high-quality images in various environments.



The underwater camera created these clear color images while submerged in a testing tank. Left is a portion of a typical resolution target; right, a section of a metal screen.

INTERESTED IN ACCESSING THIS TECHNOLOGY?

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PATENT APPLICATION 18/405303

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