csem
FACING THE CHALLENGES OF OUR TIME

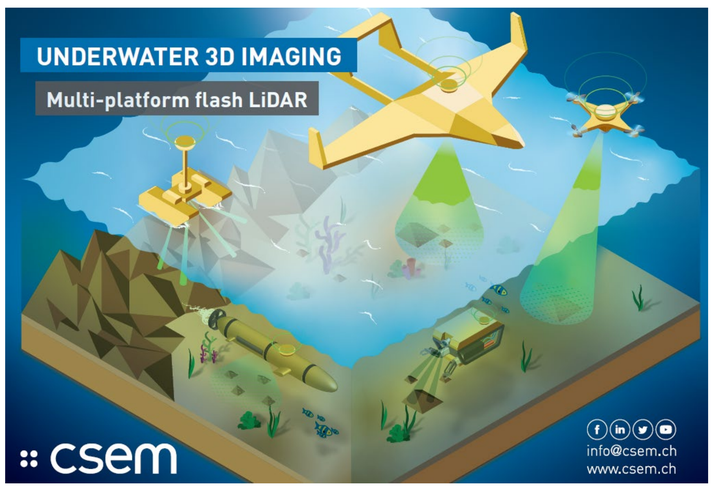
High-resolution flash lidar for underwater mapping

J. Holzer[1], D. Nguyen[1], E. Bosch[1], C. Pache[1]

[1]Centre Suisse d'Electronique et Microtechnique (CSEM), Switzerland

Flash lidar combines the speed of acoustic surveying with the resolution of optical imaging. It delivers dense, centimetre-scale 3D maps of shallow underwater environments from compact unmanned platforms.

Why flash lidar ?



A complete depth image in every snapshot.

Complementary to multibeam echo sounding and photogrammetry, flash lidar provides a centimetric precision over several meters underwater, with the following advantages:

- Snapshot acquisition, no mechanical scanning
- Direct depth information and on-board processing
- High point density and centimetric precision
- Compact and platform-ready

Prototype design

Space-derived direct time-of-flight flash lidar adapted for underwater imaging.



Field-proven underwater flash lidar prototype

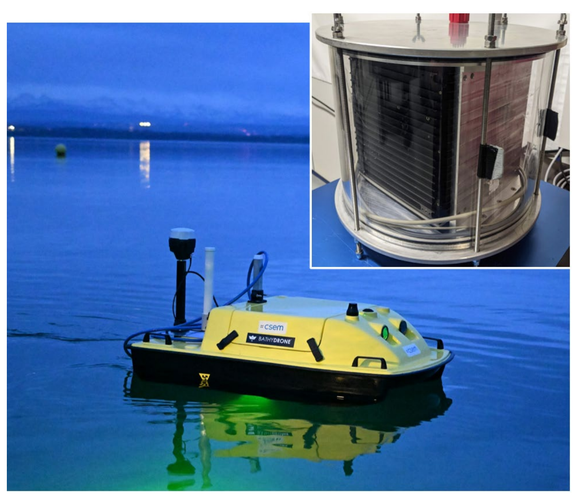
- 128 × 128 SPAD pixels
- 532 nm pulsed laser
- Up to 15 m underwater
- > 10 depth images/s
- 20 × 19.4 × 16.4 cm^3
- < 6.5 kg

Holzer, J. et al., "Space-heritage SPAD-based flash lidar for underwater 3D mapping: from system design to field demonstration," *Optics Continuum* **5**, 1466–1483 (2026).

Technology Demonstration

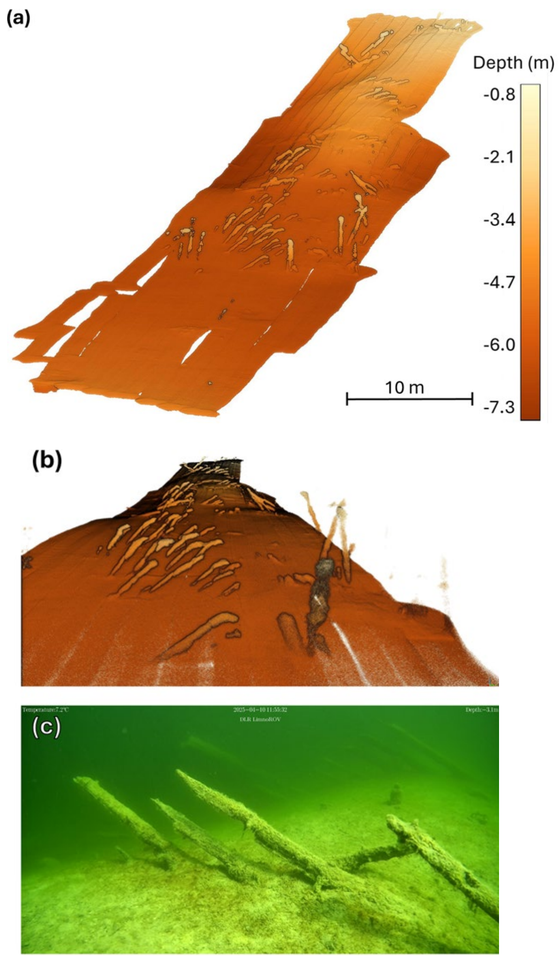
High-resolution mapping from unmanned surface vehicles.

Demonstrated at three archaeological sites under varying water depths, environmental conditions and ambient illumination. The three campaigns covered Les Argilliez in Switzerland, Roseninsel in Germany and Epidaurus in Greece.

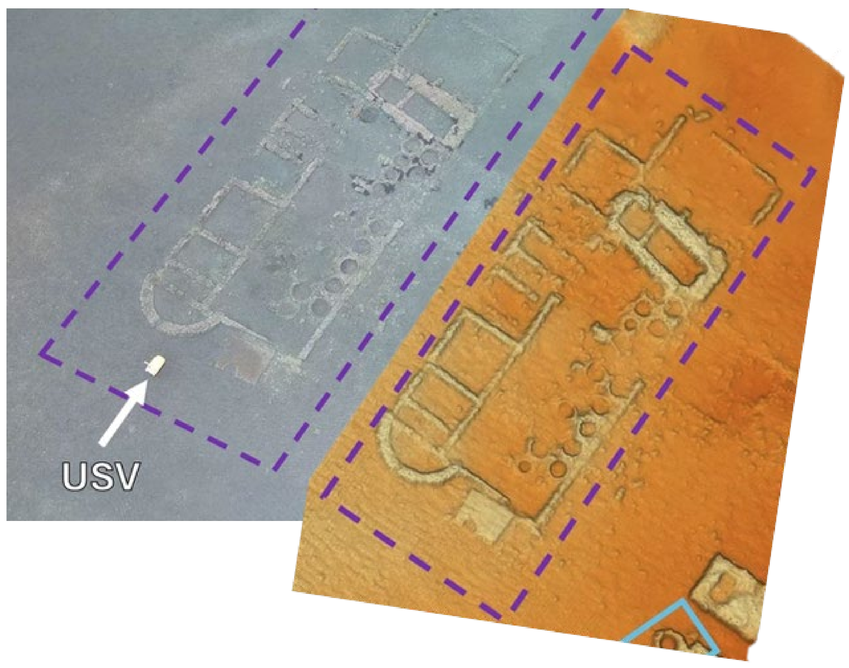


USV-mounted flash lidar during field acquisition

Les Argilliez, Switzerland: Neolithic lake dwellings



Epidaurus, Greece: a complete Roman villa mapped in 3D



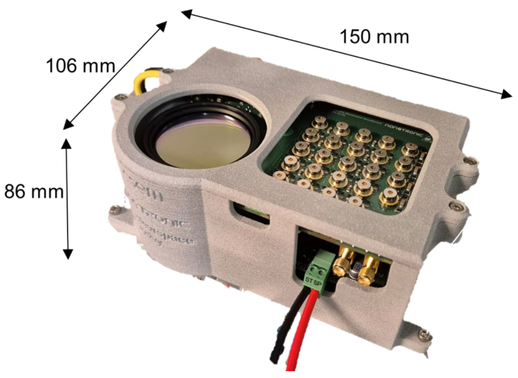
~77 points/cm²	**peak point density**	**3.8 cm** repeatability	**maximum deviation across repeated lines**	**>98%** completeness	**achieved over the principal mapped areas**

Holzer, J. et al., "Flash lidar for underwater cultural heritage mapping," *npj Heritage Science* **14**, 373 (2026).

Miniaturisation

Next-generation lidar for more versatile deployment.

- Higher resolution: 256 × 256 SPAD pixels
- Smaller and lighter: 10 × 10 × 10 cm^3
- Compatible with multiple platforms
- Embedded 3D processing



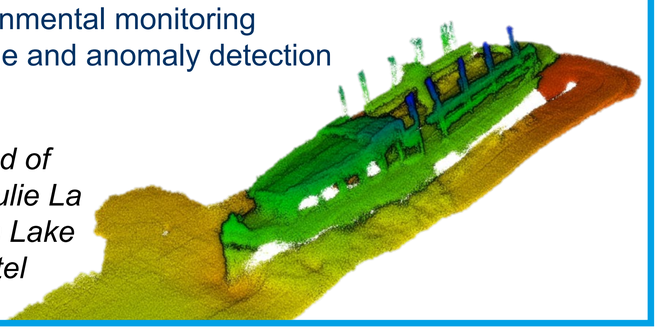
Compact 256 × 256 SPAD-based flash lidar

Beyond cultural heritage

One technology, many underwater applications.

- Infrastructure inspection
- Coastal and river mapping
- Object and obstacle detection
- Environmental monitoring
- Change and anomaly detection

Point cloud of shipwreck Julie La Rousse II in Lake Neuchâtel



Swiss LiDAR Day

Contact us now

info@csem.ch • www.csem.ch