

## Acoustic Camera

### Value Proposition

The Acoustic Camera uses sound to generate near-real-time 3D imagery through fluids that block light, giving operators an accurate view of submerged objects on the first pass rather than an inference drawn from impression blocks or sonar returns.

### Technology Readiness Level 4

### IP Information for S-129409.002

U.S. Patent No. 10,054,676-B2

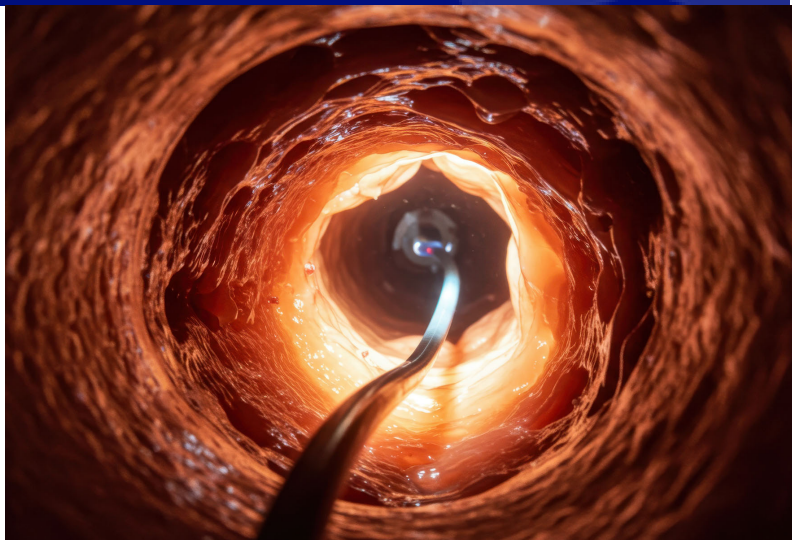
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### Overview

When water turns murky or dense with mud, sediment or chemistry, optical cameras stop being useful, and operators are left guessing about what lies on the other side of the fluid. The Acoustic Camera from Los Alamos National Laboratory replaces that guesswork with sharp 3D imagery generated from sound, achieving sub-millimeter depth resolution in near real time. Instead of inferring the size and orientation of a submerged object from an impression block or a low-frequency sonar return, an operator receives an actual shape, with depth cues and material hints, on the first pass. The result is faster decisions in environments that have historically been opaque, whether the goal is recovering a lost tool from a wellbore, checking the integrity of a net pen in a turbid fjord, or inspecting submerged infrastructure where flushing or cleaning the surrounding fluid is not an option.

The system operates by transmitting high-frequency ultrasonic pulses—typically in the hundreds of



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kilohertz range (approximately 100–800 kHz)—into the wellbore toward an object of interest. These sound waves reflect off the object and are captured by a two-dimensional acoustic receiver array. By measuring the time-of-flight and spatial distribution of the returned echoes, onboard digital signal processing reconstructs a detailed 3D image of the object in near real time. Because ultrasound propagates through drilling mud and other optically opaque fluids, the system can generate clear 3D images without requiring fluid replacement or well cleanout.

### Advantages

- **Imaging through opaque fluids:** Enables 3D visualization in drilling mud and other optically opaque, acoustically attenuating fluids where optical systems fail
- **Reduced cost and downtime:** Eliminates the need for well cleanout and accelerates diagnostic decision-making during fishing operations
- **Higher-quality diagnostics:** Provides accurate 3D information on object shape and orientation, surpassing mechanical impression methods
- **Lower operational risk:** Improves fishing-tool selection and reduces the likelihood of failed recovery attempts or well loss

*Continued on reverse*

## Advantages continued

- **Extensible platform:** Applicable to other downhole and industrial environments involving optically opaque fluids, supporting future product expansion

## Technology Description

Acoustic Camera uses a broadband piezoelectric transducer to insonify the object with frequencies between roughly 100 kHz and 800 kHz. Because attenuation in fluids scales with the square of frequency, this band is chosen as the practical compromise between mud penetration (favoring lower frequencies) and image resolution (favoring higher frequencies). Reflected pulses pass through a compound high-density polyethylene (HDPE) acoustic lens consisting of a fixed plano-concave primary element and a motor-positioned secondary element, allowing focus adjustment without changing the receiver position, and yielding an appropriate magnification factor.

The receive array is a 2D segmented piezoelectric detector submerged in sound-communicating fluid whose low sound speed provides a roughly three-fold reduction in wavelength versus water and enables a compact camera housing. Image reconstruction can use either tone-burst excitation with first-arrival extraction or, for higher resolution, frequency-chirp excitation followed by cross-correlation of the transmit and receive signals — yielding depth resolution below 1 mm at working distances of up to approximately 2 feet in drilling mud. The film allows the source and detector to share a single optical axis, eliminating the multiple reflections and aberrations introduced by semi-transparent acoustic mirrors used in earlier architectures.

## Market Applications

- **Oil and Gas**
- **Mining and Geotechnical Operations**
- **Enhanced Geothermal Systems**
- **Industrial Inspection and Maintenance**
- **Energy and Utilities Infrastructure**
- **Government and Defense**