

# MEASURING THE IMPOSSIBLE: High-Pressure Shock Wave Captured with Unprecedented Clarity



Researchers from the **Brigham Young University (BYU) Acoustics Research Group** — namely Sarah M. Young, Kent L. Gee, Traciannne B. Neilsen, and Kevin M. Leete — completed one of the most demanding acoustic measurement tasks in outdoor research: capturing the full life cycle of a high-pressure spherical shock wave with scientific precision.

Although the work was academic, the experiment demonstrates a level of measurement clarity and reliability that is highly relevant for defense and military applications, where understanding shock-wave behavior is essential for safety, modelling, and risk assessment.

The purpose of the study was to observe how a shock wave evolves as it travels through an uncontrolled outdoor environment—from the violent pressure peak immediately after the blast, to the much weaker signal that remains hundreds of meters away. For defense communities, this type of knowledge underpins a wide range of activities, including blast-effect research, protective-equipment development, and the refinement of stand-off distance models.

The challenge for the BYU team was considerable. Measuring a shock wave outside the laboratory means working with extreme sound pressure levels close to the source, rapid decay over distance, shifting meteorological conditions and the presence of environmental reflections—all of which can distort or mask the true behaviour of the wave. A single microphone type is not capable of handling this full dynamic range, so the researchers needed a setup that could survive the intense overpressure of the blast while still capturing the faint remnants of the wave far away from the source.

## The GRAS Technology Behind the Measurements

To achieve this demanding measurement profile, the BYU team deployed a combination of GRAS microphones, each chosen for its specific acoustic strengths. Close to the blast, they used **GRAS pressure microphones, such as the 40BD and 40BE**, designed to withstand the extreme overpressure and rapid rise times characteristic of shock fronts. These microphones have very low sensitivity, allowing them to record the violent onset of the wave without clipping or distortion.

Further from the blast, the team used **GRAS free-field microphone sets**, including models like the **46BG**. These microphones are engineered for high precision in open-air environments and offer the sensitivity needed to capture the weakening signal as the shock decayed with distance. Their ability to deliver accurate recordings at lower sound-pressure levels made them ideal for tracking the wave's extended tail hundreds of meters from the source.

Together, the pressure microphones and free-field microphones formed a staged measurement chain that matched the acoustic demands of each distance zone. By using the right GRAS technology in the right place, the researchers ensured that the full shock-wave signature—from peak to decay—was captured cleanly and without compromise.

The entire array was calibrated before the experiment, mounted at carefully selected heights to reduce ground reflections, and operated without protective grids to avoid unintended influence on the incoming wave. This meticulous setup allowed the researchers to follow the shock wave's evolution with exceptional fidelity.

## A Breakthrough in Outdoor Shock-Wave Measurement

The result was a remarkably clear data-set, showing how the waveform evolved from a sharp, high-pressure discontinuity into a weaker acoustic signal as it propagated outward. The measurements provided reliable material for comparing real-world shock behaviour with theoretical weak-shock decay models and offered valuable insight into how environmental factors shape propagation outdoors.

For the defense community, the implications are substantial. Although this experiment was conducted in an academic setting, the methods and data quality directly support fields where precise knowledge of shock-wave behaviour is critical. High-quality outdoor measurements of this type inform blast-wave modelling, support the development of protective measures, and contribute to more reliable assessments of exposure and risk. They also demonstrate how thoughtful microphone selection and deployment—supported by robust GRAS technology—can make it possible to capture acoustic events that are traditionally viewed as nearly impossible to measure in the field.

This case stands as a compelling example of how advanced acoustic measurement tools can generate trustworthy, high-value data for both scientific research and defense-relevant applications. If understanding real-world shock behaviour is the goal, this experiment shows that it can indeed be measured with unprecedented clarity.

## About GRAS Products — What Makes Them the Right Tools for This Job

GRAS is widely recognized as a leading manufacturer of high-precision measurement microphones and acoustic test equipment, serving demanding fields like aerospace, automotive, aerospace, defense, environmental acoustics and R&D.

For a measurement challenge as severe as capturing a high-pressure shock wave outdoors, GRAS offers microphone sets designed precisely to handle extremes—both intense blasts and delicate decays. Key types and features include:

- **Pressure Microphone Sets (e.g. GRAS 46BG / cartridge GRAS 40BD)** — Built to withstand very high sound pressure levels (SPL). The 46BG, for instance,

a strong, overpressure event must be recorded without clipping.

- **Free-Field Microphone Sets (e.g. GRAS 46BE / cartridge GRAS 40BE)** —

Designed to accurately capture sound pressure in open air (“free field”) environments, these mics are sensitive enough to record lower-level sound at longer distances or after a shock has decayed. The 46BE  $\frac{1}{4}$ ” free-field set, for example, covers a wide frequency range (from a few Hz up to 80 kHz) and handles high SPL as well as high-frequency content—making it well suited for measuring acoustic pulses, transients or decaying shock waves.

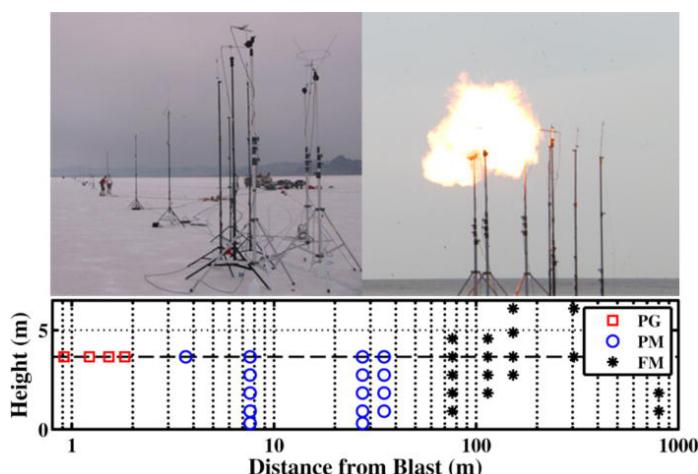
- **Wide Product Range and Versatility** —

GRAS offers a broad portfolio of microphone sets, from  $\frac{1}{4}$ ” and  $\frac{1}{2}$ ” pressure or free-field mics, to specialized rugged versions intended for harsh environments (extreme temperatures, vibration, dust, moisture)—for example the  $\frac{1}{2}$ ” free-field sets built for automotive NVH testing. This versatility allows researchers to pick the optimal microphone type depending on the measurement conditions: near-field overpressure, far-field decay, harsh environment, high frequency, etc.

- **Calibration and Reliability** —

All GRAS microphones leave the factory with traceable calibration under controlled conditions. For long-term measurement campaigns, GRAS offers both “Traceable Calibration” and “Accredited Calibration (ISO 17025)” services to ensure consistency, accuracy, and data integrity across tests.

Because of this carefully designed product ecosystem—combining robustness, sensitivity, and versatility—GRAS microphones are especially well suited for challenging acoustic tasks such as outdoor blast-wave measurements.



Picture from the publication. “(Color online) View of the microphone array on the Bonneville Salt Flats, a balloon explosion, and a schematic of piezoresistive gage (PG), pressure microphone (PM), and free-field microphone (FM) locations.”

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Outdoor-measurements-of-spherical-acoustic-shock

supports dynamic ranges up to 184 dB while maintaining reliable sensitivity. Such pressure mics are ideal for measuring sound pressure at boundaries (or “at the wall of the pressure wave”) and are commonly used when

