SAND2024-04866C

The First Detection of an 'Artificial Meteor' by a Large N Acoustic Array

Elizabeth A. Silber[1], Daniel C. Bowman[1], David P. Eisenberg[2], Brant Beck[2], Grant Bracht[2], Cory Van Beek[2], Nathan Weinstein[2], Girish Srinivas[2]

[1]Sandia National Labs, Albuquerque, NM, USA; [2]TDA Research Inc., Wheat Ridge, CO, USA (esilbe@sandia.gov)

Abstract #: 10715

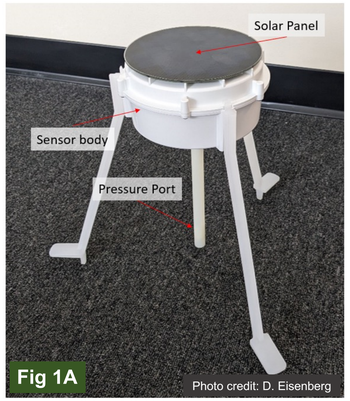
SAND2024-04866C

SSA Conference, Anchorage, AK, 29 April–3 May 2024

Introduction

- On September 24, 2023, NASA's OSIRIS-REx sample return capsule (SRC) landed in Utah, bringing delicate particles of the nearby asteroid Bennu to Earth.
- SRC are considered 'artificial meteors' since they are analogous to natural extraterrestrial objects impacting Earth [1]. The SRC entered the atmosphere at hypervelocity over California and flew over Nevada, before slowing down and landing at the Utah Test and Training Range (UTTR).
- Dense nodal acoustic arrays, like their seismic cousins, can provide detailed signal information that is otherwise unavailable using standard array installations.

Sensors



TDA's sensors (Fig. 1AB) have two primary benefits:

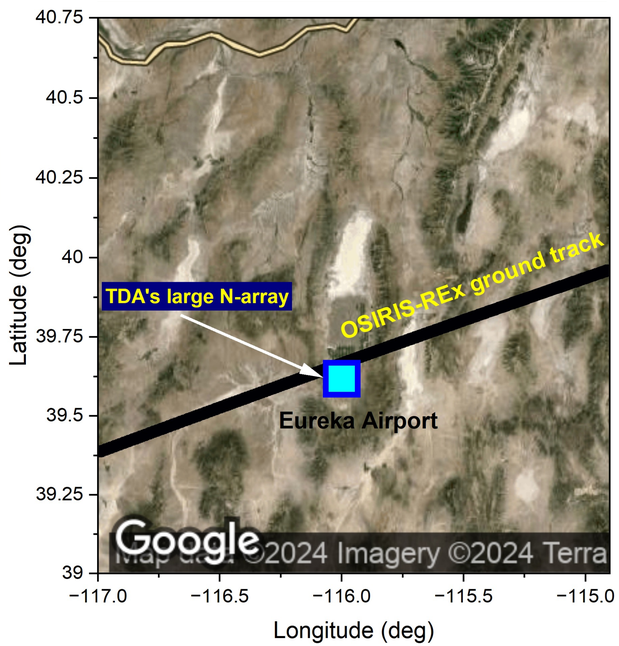
(i) low cost and (ii) specifically designed to be networked into large and dense arrays with 100s of sensors and wirelessly stream data to a central computer.

- The array design is modular and flexible (Fig. 1CD), and its size can be anywhere from 5 to 500 sensors added in groups of five.
- Sensors have a sensitivity of <0.1 Pa and a sampling frequency of 200 Hz (that can be increased up to 330 Hz if needed).
- Each sensor has an on-board battery with a battery lifetime of ~9 days, and also come equipped with a solar panel that will recharge a day's worth of power in 1-2 hours of sunlight and will fully recharge the sensors in 9-13 hours.
- Sensors use a differential GPS system with accuracy of < 1cm and clocks from all sensors in the array are synced to within 1 ms.
- The sensors weigh 1.55 lbs each and are 13 inches tall when fully assembled.
- TDA's sensors minimize wind noise by sampling at only 0.5 inches off the ground, taking advantage of the ground's boundary layer to reduce effective wind speed by 75%.

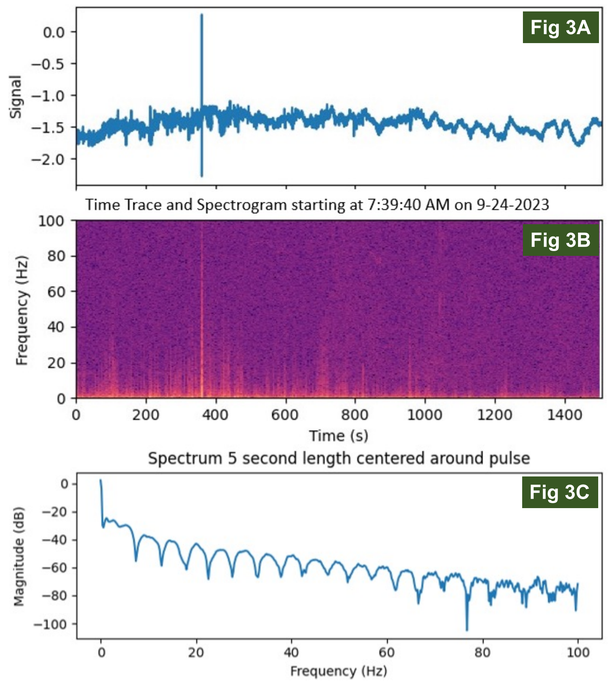
Figure 1: (A) TDA's sensor; (B) sensors shown before being deployed in anticipation of the OSIRIS-REx SRC overflight; (C-D) sensors deployed in the field.

Data collection and signal detection

Figure 2: Map showing the OSIRIS-REx ground track and Eureka Airport (Nevada). TDA's large N-array was deployed at the airport, almost beneath the nominal trajectory.



- A large N-array with 115 sensors was deployed in Eureka, Nevada enclosing a 100 x 100 m square. The location was near the nominal ground track and approximately 60 km beneath the trajectory (Fig. 2).
- The array started collecting data at 01:23 PM (local time) on 9/23/2023 and stopped collecting data at 08:05 AM on 9/24/2023.
- At the time of the reentry (7:46 AM on 9/24/2023), 114 of the sensors were collecting data



- The large N-array readily detected infrasound signatures related to the ballistic shockwaves generated by the SRC.
- The strong pulse can be seen in Fig. 3 (unfiltered timeseries).
- The first detection of an 'artificial meteor' by a large N-array demonstrates its utility and capability to capture signal from similar sources

Figure 3: (A) Time trace from one sensor; (B) spectrogram; (C) Frequency spectra over a 5 second window centered around the hypersonic pulse.

Please see our other posters in this session

References

[1] Silber, E. A., Bowman, D. C., & Albert, S. (2023). A Review of Infrasound and Seismic Observations of Sample Return Capsules since the End of the Apollo Era in Anticipation of the OSIRIS-REx Arrival. *Atmosphere*, *14*(10), 1473.

Sandia National Laboratories is a multimission laboratory operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.