National Aeronautics and Space Administration

Semi-Permanent Fiber Seismic Network at the Goldstone DSN Station

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Program: Strategic R&TD

Project Objective:

In this effort, the objective was to create a semi-permanent installation of Distributed Acoustic Sampling (DAS) system at the DSN's Goldstone array. This system interrogates existing fiber-optic cables, which then act as an array of distributed seismometers – approximately one per meter across >20 kilometers . Simultaneously, the system is ready for emergent deployment on commercial fiber-optic cables for emergent deployment during major seismic activity (e.g., Ridgecrest, CA earthquakes).

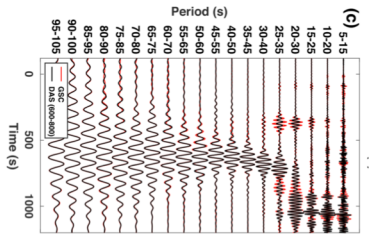
FY18/19 Results:

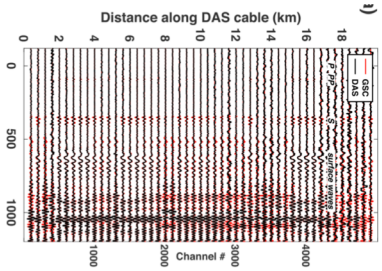
• The scope of this task focused on the semi-permanent installation and characterization of a commercial DAS unit at the Goldstone DSN. Under previous PDF funding, we collected 2 months of DAS data in Goldstone using the 20-km long optical fibers and a loaned commercial system. Data analysis is still underway for this experiment, but passive observation allowed recording of multiple teleseismic events. An additional active source survey was also conducted using relatively low-energy hammer and dropped weight sources analogous to low-energy, but repeatable sources which may be practical for planetary deployment. This system was installed "off-network", in that remote access was only available via low-bandwidth commercial cellular links to ease the challenges of installation activities.

•Subsequent emergent installation of a DAS unit in Ridgecrest, CA immediately following the July 2019 earthquakes provided unprecedented views of aftershocks and their seismic wave propagation (see below figure). Immediately after this event, our team partnered with Optasense and Silixa DAS manufacturers to install their systems in Olancha, CA - just outside of Ridgecrest - on existing commercial fibers (placed for telecommunications). Combined with remote access capability, these systems allowed for a nearly 30 km stretch of fiber, parallel to Hwy 395, to be observed in real-time and detailed data to be stored during the numerous aftershocks. This data was then transferred via hard drives for analysis at Caltech.

•Major Accomplishments:

– Acquired a commercial DAS system capable of greater than 10 km optical fiber interrogation.
– Created a deployment kit for standalone installation with telecommunication networks
– Built a low-cost RTK GPS system, configured for use in calibration and verification of emergent deployments. This system will travel with the DAS unit for quick deployment and validation of deployed systems.

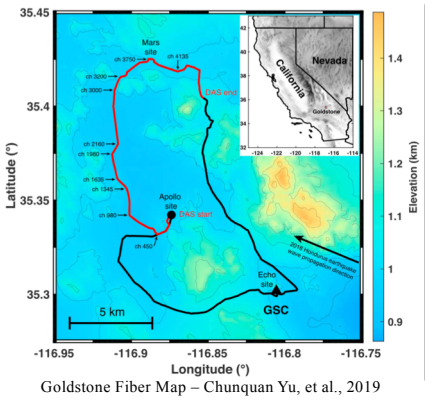




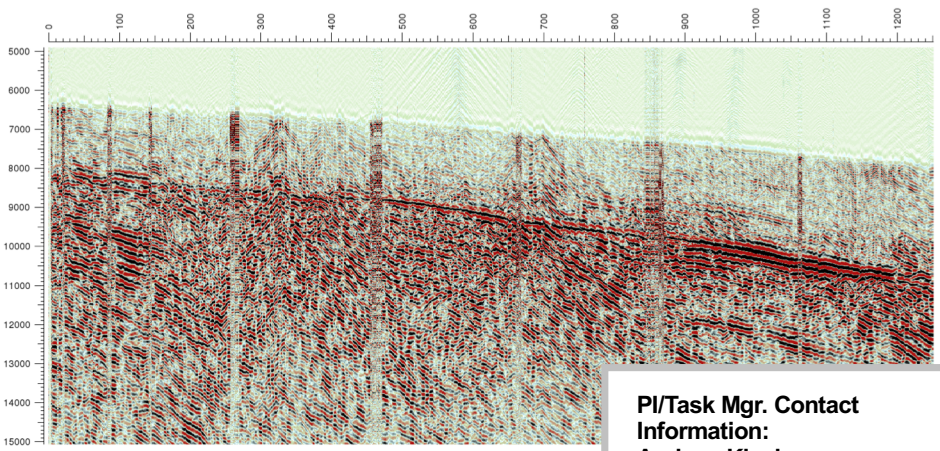
Goldstone Fiber Map – Chunquan Yu, et al., 2019

Benefits to NASA and JPL (or significance of results):

Seismological measurements are of critical importance to obtain detailed information on planetary interiors. Recently active and proposed planetary seismic deployments have relied on a single seismic instrument due to the limitations of deployment and limits on mass and power. However, most recent advances in seismic imaging have relied on arrays of seismic instruments. Distributed Acoustic Sensing (DAS) is a new technology that turns every meter of a long optical fiber into a seismometer, by sending laser pulses through the fiber and monitoring changes of the Rayleigh scattering due to stretching of the fiber. DAS allows a dense (>1000 sensors) seismic network with technical performances comparable to those of geophones at frequencies higher than 1Hz while still able to provide high-fidelity waveforms at lower frequencies. Because fiber cables can be engineered to be survive in harsh environment (e.g., extreme temperatures, high radiation), a DAS array is possible on planetary surfaces when only the interrogation units can be protected at one site. On Earth, DAS can take advantage of dark (unused or backup) fiber deployments, providing unprecedented views of seismic events in both permanent installations, or quickly installed for emergent usage.



Goldstone Fiber Map – Chunquan Yu, et al., 2019



Ridgecrest Aftershock as recorded by a DAS system – Zhan, et al., 2019

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1) C. Yu, Z. Zhan, N. Lindsey, J. Ajo-Franklin, M. Robertson, "The Potential of DAS in Teleseismic Studies: Insights from the Goldstone Experiment", Geophysical Research Letters, 2019

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