# Curtin In-Situ GeoLab – advancing geophysical sensing.

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## SUMMARY

The Distributed Acoustic Sensing (DAS) is a novel approach in sensing which constantly increasing its presence in various geophysical applications. It is paramount to understand the measurements, their limitations and performance of the technology for proper utilisation. Benchmarking emerging technologies against conventional receivers and across different equipment designs is also essential. Curtin University has built the In-Situ GeoLab Research facility and accumulated a comprehensive reference datasets that includes data with conventional geophones as well as new distributed sensors. The Curtin GeoLab based on a deep well instrumented with fibre optic sensing cable, surface deployed helical fibre cables, a number of controlled sources. Here we present results of recent DAS borehole trials and DAS surface experiments at the facility.

**Key words:** DAS, DTS, Curtin In-Situ GeoLab, fibre-optics, seismic.

## INTRODUCTION

The distributed fibre optic (FO) sensing technology made significant progress in the developments of instrumentations and application methodologies. Distributed fibre-optic sensing is being actively used in various exploration and monitoring applications. Dedicated research laboratories and instrumented sites contributed a lot to acceleration of the technology development.

Accelerated development of the DAS technology is extensively supported by academic research and many universities and companies established dedicated laboratories and test sites (Dou et al. 2017; Lindsey et al. 2017; Correa et al. 2018; Merry et al. 2020; Titov et al. 2020; Zulic et al. 2020; Wuestefeld et al. 2021). GeoLab Research Laboratory is established at Curtin University and is located at the University campus in Perth, Western Australia. The facility is designed for conducting applied geophysical research, equipment testing and training of students and industry personnel. Availability of an in-situ test facility allows conducting various controlled experiments and testing new ideas to expedite technological developments. Curtin GeoLab was initially built around a deep instrumented well. The key component of the facility is a 900 m deep fibreglass cased well instrumented with a fibre optic cable, which is cemented behind the casing. Recently we obtained an opportunity to compliment the setup with near-surface installation comprised of some unused dark fiber already installed on campus and a purposely buried sensing cable.

Numerous experiments focused on fibre optic technology have been carried out at the laboratory over the recent years (Pevzner et al. 2018a; Pevzner et al. 2018b; Correa et al. 2018; Tertyshnikov et al. 2019; Zulic et al. 2020). One of the important aspects in advancing technology is to have an ability to benchmark against it the standard and well regarded sensors and approaches. At the GeoLab we have created an open access reference seismic dataset based on the downhole measurements with standard 3C geophones as well as with fibre optic sensors. Here we present work on the extension of this reference data including acquisition of the walkaway VSP. Such datasets allows for evaluate performance of new developments in DAS equipment against conventional tools. We also present a few results from the ongoing tests including a cable trenched in the near-surface.

## REFERENCE BOREHOLE SEISMIC DATASET

The GeoLab research site is located at Curtin's main campus in Bentley in the middle of the large metropolitan area of Perth city, WA. Such location comes with some great advantages as easy access to a deep well for the experiments somewhat combined with difficulties using the land around the well for the active seismic surveys.

A number of datasets were acquired including multi-offset VSP using conventional 3C geophones, borehole distributed fibre sensors, dense zero-offset VSP with conventional 3C geophones, and borehole distributed fibre sensors. The spatial multi-offset vertical seismic profiling (VSP) survey has been designed to utilise accessible areas on the playfields and oval to accommodate locations for a seismic source. Figure 1 shows the map of the multi-offset (walkaway) VSP survey.

There were several sets of seismic receivers utilised for the acquisition. Conventional 3C geophone data was recorded using ten level Sercel SlimWave. Receiver step was 10 m covering the entire well depth range from 10 to 870 m.

The geophone string had to be moved nine times to collect data along the well, as such every shot point location had to be repeated the same number of times. Emphasis of the survey was to record dense spatial borehole seismic dataset with conventional receivers.


**Figure 1. The Curtin In-Situ GeoLab VSP and surface dark fibre surveys acquisition map. Red dot – location of the GeoLab well. Blue dots – location of the near and far VSP offset shot points. Purple dots – locations of the walkaway VSP shot points. Pink dots – location of 3C geophones. Orange dots – locations of the surface seismic (dark fibre) survey. Green dots are determined locations of the dark fibre.**

The fibre optic cable installed behind the well casing was also utilised for the acquisition. As the cable has 4 cores of the single-mode fibre, it was possible to record data simultaneously on two different fibre optic interrogators: iDAS v2 (Silixa Ltd) and Treble (Terra15 Ltd). These two interrogator have different design and architecture, the data were acquired on both of them for the purpose of performance comparison. Interrogators were housed in the NGL office where a fibre optic cable from the well is terminated. Recording parameters of the Silixa iDAS v2: 10-meter gauge length, pulse width of 5 m and sampling interval was 0.25 m; Treble allows to post-process data with different gauge lengths and pulse width was set to 5 m.

Two Inova UniVib 26,000 lbs seismic vibro trucks were used as seismic sources. A total of 48 source location was used to excite the seismic wavefield (Figure 1, purple dots). The sweep parameters: 24 s length linear sweep with 6 to 150 Hz frequency range and 0.5 s cosine tapers. Radio link was established between the vibroseis trucks and VSP recording system. The recording system was also recording GPS time stamps for each shot. Interrogators were recording continuously and were recording GPS time as well. That allowed synchronisation of all systems in the post-processing. Figure 2 shows example of the shot gathers from near and far offset for geophone and DAS data. Acquisition of a zero-offset VSP dataset with densely spaced three component (3C) geophones and DAS for the accurate velocity estimation was conducted with distance between geophones along the well of 5 m and the same recording parameters for the interrogators as for the multi-offset experiment.

In addition to seismic acquisition, a BandWeaver distributed temperature sensing (DTS) unit was connected to a multimode fibre core of the cemented cable to record temperature variations during the survey.

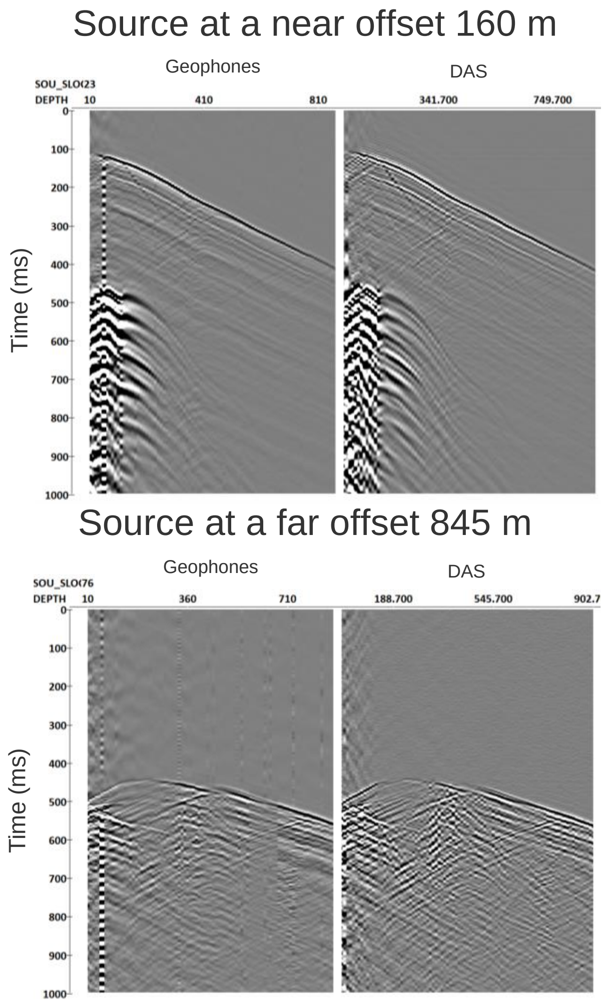


**Figure 2. Example of the shot gathers from near and far offset for geophone and DAS data.**

## EXPANDING TO SURFACE DAS SENSORS

GeoLab research laboratory is constantly looking for paths to extend its capability and to expand its options for experiments and studies. During the construction of new surface infrastructure at the University, a deployment of a 300 m section of 30 deg pitch HWC cable into one of those trenches was arranged. The purposely buried sensing cable was later connected through the unused cores in the existing communication cables ('dark fibre') to the research facility.
Unintentionally, information about the exact location of the buried HWC cable has been confused. We carried out a surface seismic survey with a purpose to collect data with the conventional 3C geophones deployed on top of the buried HWC cable. The objective was to collect data over several source lines at various azimuth to the FO cable to study its directional sensitivity against geophones. Thirty eight 3C sensors were deployed above the assumed location of the cable (pink dots in Figure 1) with a step of 5 m between geophones. Five shot lines

were arranged to cover various offsets and direction to the FO cable. The shot point distance along the source lines was 10 m. Overall, 89 shot point were acquired (orange dots in Figure 1). The same Inova vibroseis truck was used as a source with the same sweep parameters as for the VSP survey. Silixa iDAS v2 was used to interrogate the dark fibre: 10-meter gauge length, pulse width of 5 m and sampling interval was 1 m. Data revealed that indeed the location of HWC cable is not as it was expected as it was not possible to recognise a similar wavefield pattern as on the geophone data.

To determine the actual position of the HWC fibre optic cable and to check locations of other segments of the dark fibre, we applied the multilateration technique using active shot points as anchors. The velocity model for this approach was estimated using conventional geophones. Figure 1 displays the result of these calculations with green dots representing channels along the fibre optic cables. Next step would be to reacquire the active seismic data with 3C geophones positioning them above the actual fibre cable.

## CONCLUSIONS

Here we present just a few experiments conducted at the GeoLab research laboratory at Curtin University. The laboratory is focusing on various experiments and tests to advance the distributed acoustic sensing. The reference borehole seismic dataset acquired with standard 3C geophones and cemented DAS cable is collected at the facility for benchmarking new DAS developments and is available on the website of the Curtin Centre for Exploration Geophysics (https://ceg.curtin.edu.au/resources/conferences-and-symposiums/ ). We continue to develop the facility to expand opportunities for new studies. Recently we included a long segment of the dark fibre with the purposely buried helical cable. Undoubtedly, establishing such research facilities across the globe greatly contribute to accelerate developments in geophysical technologies.

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