



Detection of aircraft noise with a buried fibre-optic array

**Boris Gurevich (1), Konstantin Tertyshnikov (1), Roman Isaenkov (1),
Mikhail Vorobev (1), and Roman Pevzner (1)**

(1)Centre for Exploration Geophysics, Curtin University, Perth, Australia

Abstract - Buried distributed acoustic sensor (DAS) arrays are known to detect and monitor various sources of passive seismic waves, both natural and anthropogenic. But can buried DAS detect sources in the atmosphere such as aircraft? There is some evidence of aircraft signal on DAS data, but more research is needed to understand the detection capabilities and estimate flight parameters. A four-week continuous DAS recording with a gauge length of 10 m using a telecommunication array buried beneath the Curtin University campus in Perth, Western Australia shows distinct signatures of aircraft in the frequency range of 70 to 120 Hz at distances of up to 2-3 km. However, the system detected only propeller and not jet aircraft, which are known to emit sound of a higher frequency and thus require a smaller gauge length.

1 INTRODUCTION

Distributed acoustic sensors (DAS) can detect and monitor various sources of seismic energy, both natural (proximate, regional and remote earthquakes; ocean storms) and anthropogenic (mine blasts, vehicle and pedestrian traffic) (Lindsey et al., 2017). Most of these sources generate seismic waves, and thus can be detected with any seismic sensors, including DAS. An intriguing question is whether buried DAS cables not necessarily tightly coupled to the ground can detect aircraft noise generated in the air. Such detection may be useful for independent monitoring of air traffic by leveraging vast existing fiber-optic telecommunication networks. Previous studies show that aircraft noise has a distinct signature easily detectable by geophones (Meng & Ben-Zion, 2018). Yet detecting such noise using a buried DAS array may be challenging as most of the sound is likely to be reflected by the earth surface. Fang et al. (2020) show that some aircraft can be detected while others cannot. We explore detection of aircraft noise by a buried DAS array and estimation of the detection range, aircraft position and speed.

2 FIELD EXPERIMENT

To explore the possibility of detecting aircraft noise, we recorded DAS data continuously over four weeks in 2023 using a telecommunication fibre-optic cable buried beneath the Curtin University campus in Perth, Western Australia, about 10 km from the Perth International Airport (Tertyshnikov et al., 2021). The cable is buried beneath the campus grounds around the Curtin stadium with a maximum spread of ~ 600 m in both north - south and east – west directions. The data were acquired with a gauge length of 10 m using DAS interrogators from two different vendors. Air traffic data from FlightRadar24.com were analysed to identify aircraft that passed within 1 to 2 km from the array. For each such aircraft, a spectrogram (Welch periodogram: short-time Fourier transform) was computed for segments of 5 to 10 minutes in duration around the time the aircraft was the closest to the array.

3 RESULTS

Spectrograms of aircraft noise show a narrow-band signal whose frequency decreases with time as the aircraft is passing in the vicinity of the receiver (Meng & Ben-Zion, 2018). This frequency shift is caused by the Doppler effect, as the intrinsic frequency emitted by the aircraft (80-100 Hz) is shifted in proportion to its apparent speed with respect to the position of the receiver. DAS spectrograms corresponding to passing aircraft show that some of them do show the distinct Doppler pattern as shown in Figure 1a. However, this pattern was only observed for turboprop airplanes. The noise from jet aircraft has a higher frequency, which cannot be detected with a DAS

gauge length of 10 m. We have detected jet aircraft using a smaller gauge length, but data analysis requires further investigation. The variation of the central frequency with time was used to estimate the intrinsic frequency of the aircraft (83 Hz), the shortest distance between the aircraft and sensor (600 m) and the aircraft ground speed (365 km/h). This speed co-incides with that given by FlightRadar24 at that point (Figure 1b). Since DAS is multi-channel recording, it is an antenna that can be used to estimate the location of the aircraft and its trajectory in real time.

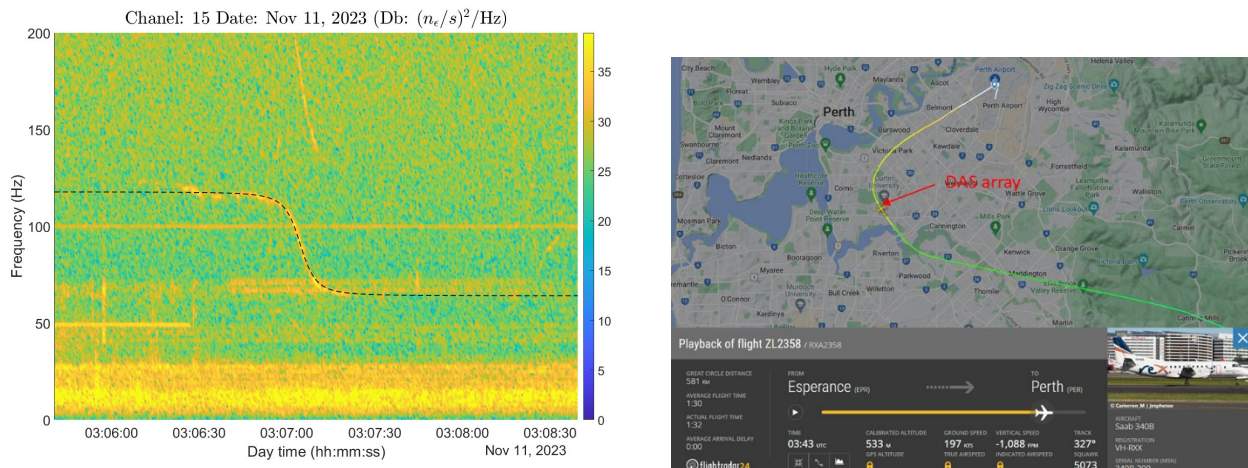


Figure 1 (a) An example of a spectrogram of DAS data corresponding to an airplane passing directly above the DAS array. The dashed line shows the variation of frequency with time for an airplane at the distance of 600 m and speed of 365 km/h. (b) corresponding flight path and data from FlightRadar24

4 CONCLUSIONS

Propeller aircraft are detectable on spectrograms of DAS data by their characteristic Doppler signature. Their parameters and trajectory can be estimated (using multiple DAS channels). The detection range is about 2 to 3 km. Detecting noise from jet aircraft requires a smaller gauge length.

ACKNOWLEDGEMENTS

The authors acknowledge the Australian Department of Industry, Science and Resources for the 2021 Global Innovation Linkage (GIL111000114) grant funding, the sponsors of the Curtin Reservoir Geophysics Consortium, and Gang Fang of Shandong University and Yunyue Elita Li of Purdue University for useful discussions.

REFERENCES

- Fang, G., Li, Y., Zhu, T., & Barak, O. (2020). *Characteristics of airplane-induced ground motion recorded by three-component(3-C) geophone and distributed acoustic sensing (DAS) in cities*, AGU Fall Meeting
- Lindsey, N. J., Martin, E. R., Dreger, D. S., Freifeld, B., Cole, S., et al. (2017). Fiber-Optic Network Observations of Earthquake Wavefields. *Geophysical Research Letters*, 44(23), 11,792-711,799.
- Meng, H., & Ben-Zion, Y. (2018). Characteristics of Airplanes and Helicopters Recorded by a Dense Seismic Array Near Anza California. *Journal of Geophysical Research: Solid Earth*, 123(6), 4783-4797.
- Tertyshnikov, K., Yurikov, A., Isaenkov, R., Sidenko, E., Bona, A., & Pevzner, R. (2021). Where on Curtin University Campus is the Dark Fibre? , 2021(1), 1-5. <https://doi.org/https://doi.org/10.3997/2214-4609.202113129>