Cognitive GEO-LEO Dual Satellite Networks: Multibeam Sensing

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Introduction

- Cognitive GEO-LEO Dual Satellite Network integrates geostationary and low Earth orbit satellites with adaptive cognitive radio technology to optimise spectral efficiency, network reliability, and global communication coverage.
- Multibeam sensing is performed to identify the presence of primary user transmission in the network.
- It allows the secondary user to find transmission opportunities in the time, frequency and spatial domains.

Aims

Our objective is to study GEO multibeam behaviour to analyse:

- the transmission patterns in time, frequency and spatial domain.
- the correlation between multi-beam transmissions.

Methods

- Capture GEO satellite signals from two separated beams.

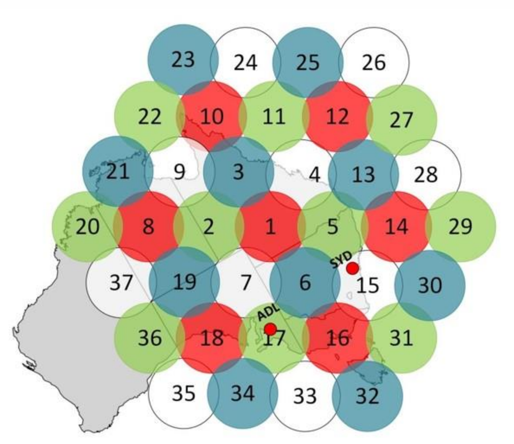

Fig. 1. Inmarsat-4 F1 frequency reuse scheme.

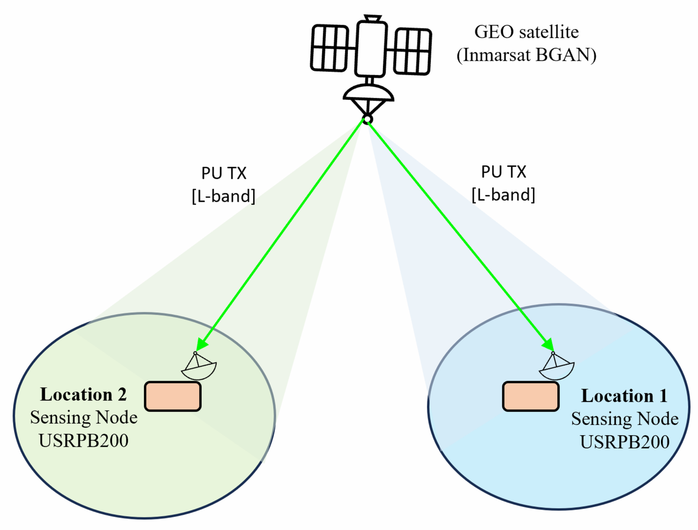

Fig. 2. System model.

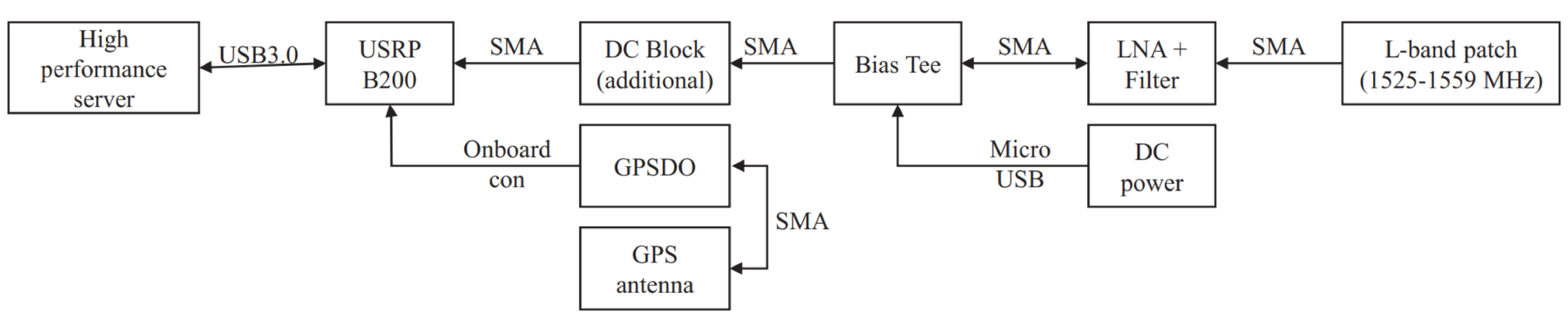

Fig. 3. Component view of the GEO signal sensing node.

- Analyse captured data.

Cross spectral density (CSD) analysis

$$P_{X_1X_2} = \mathcal{F}(R_{X_1X_2}) = \frac{1}{T}\sum_{t=0}^{T} X_1 \cdot X_2^*$$

Visually assess the correlation

$$Z_{12} = X_1 \cdot X_2^*.$$

Results

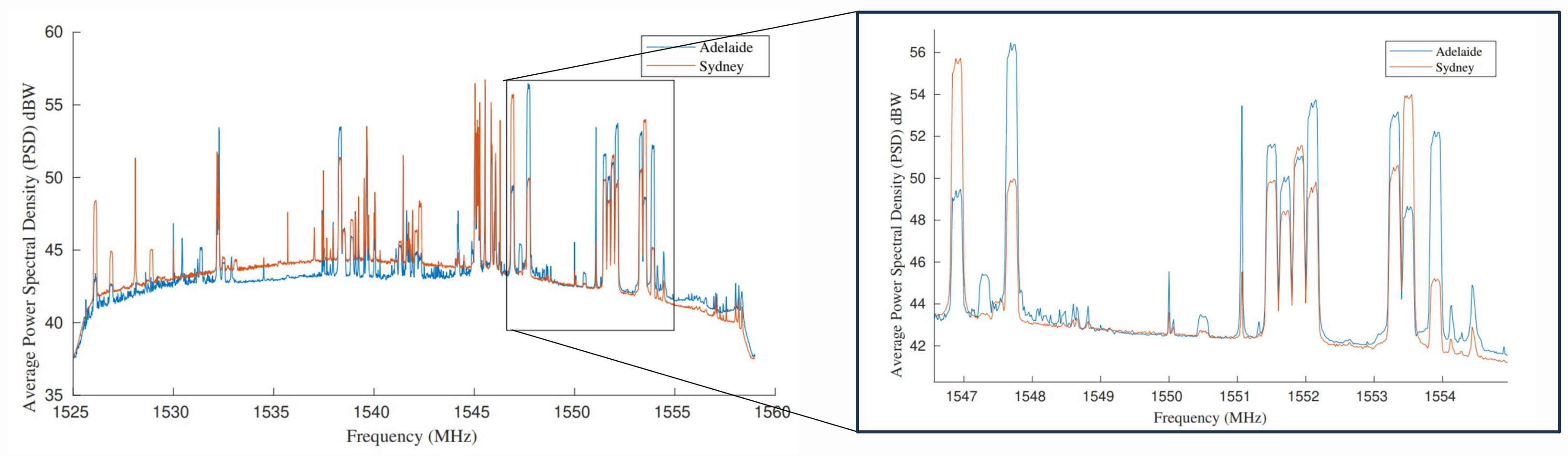

Fig. 4. Average Power Spectral Density (PSD) plot.

The two beams exhibit similar transmission characteristics in certain frequency bands.

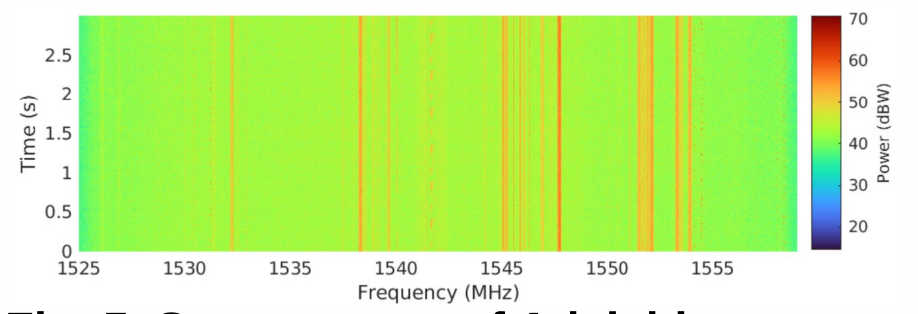

Fig. 5. Spectrogram of Adelaide capture.

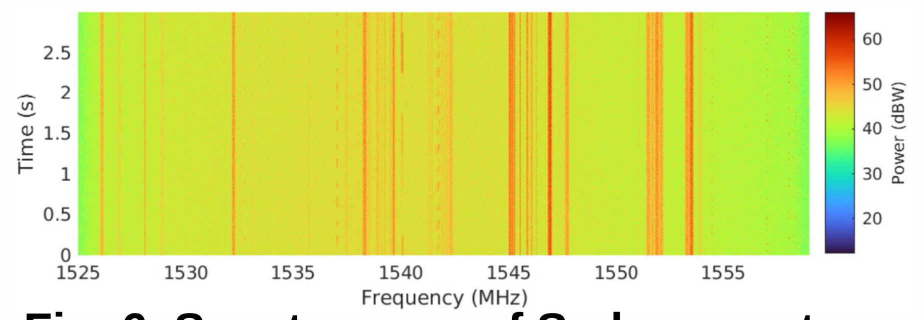

Fig. 6. Spectrogram of Sydney capture.

In these spectrograms

- yellow color represents low power signals
- red strips represent high-power transmissions.

A noticeable relationship exists between the two spectrograms.

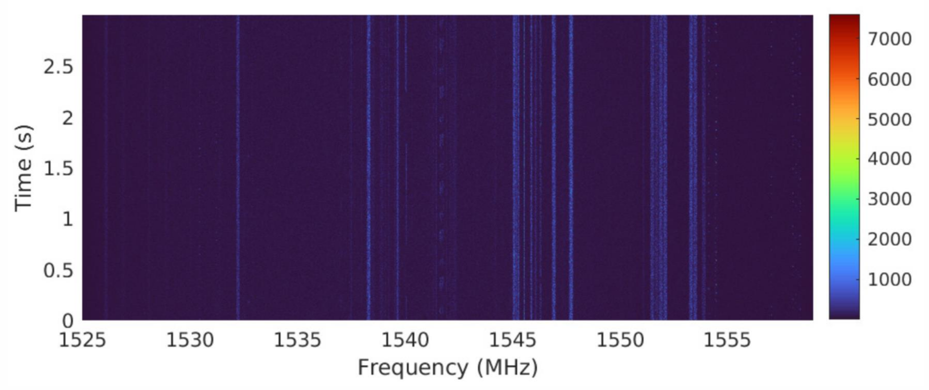

Fig. 7. Correlation analysis.

There is a correlation between the Sydney and Adelaide beams.

Conclusion

- Observe detectable leakage signals from adjacent spot beams.
- Spectrum sensing in LEO satellites is feasible.

References

[1] K. Weththasinghe, Q. T. Ngo, Y. He, B. Jayawickrama, and E. Dutkiewicz, “Cognitive GEO-LEO Dual Satellite Networks: Multibeam Sensing,” in Proc. IEEE Int. Sympos. Commun. Inf. Tech. (ISCIT), 2024.

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