Analysis of RF signatures for Space Domain Awareness using VHF radar

Emma Heading[1], Si Tran Nguyen[1], David Holdsworth[1,2], Daniel Field[2] and Iain Reid[2,3]

1: Defence Science and Technology Group, Edinburgh, SA, 5111

2: School of Physical Sciences, University of Adelaide, Adelaide, SA, 5000

3: ATRAD, 20 Phillips Street Thebarton, SA, 5031

Detecting, tracking and identifying space objects is a prominent area of research largely driven by an increase in space debris competing with requirements for more satellites being launched into orbit. Space debris is of particular concern as it has the potential to cause collisions and interfere with the operation of telecommunications, GPS systems and weather forecasting systems[1]. Additionally, mega constellations such as Starlink increase the risk of meteor collisions, changes to the chemistry of the Earth's upper atmosphere and danger upon re-entry to the Earth's surface[2].

Radar sensors are arguably underutilized in the Space Domain Awareness (SDA) effort and offer unique advantages over more commonly used optical sensors including the capability of wide area surveillance as well as operating in day, night and all weather conditions. The VHF radar in Buckland Park, South Australia, primarily performs lower atmosphere and wind profiling measurements but has reliably demonstrated observations of satellites[3]. Micro Doppler analysis has the potential to provide a unique RF signature based on rotational motion of the satellite.

Radar observations of satellite rotational motion are presented for the first time using the Buckland Park VHF radar system. The processing requirements to extract micro Doppler information from the radar data is discussed with analysis and interpretation of the results. We aim to address the question: can useful micro-Doppler features be extracted from space objects at VHF for potential use in automatic classification algorithms. Initial results are shown in Figure 1 for Telkom 3 highlighting the time varying sinusoidal Doppler frequency induced from the satellite rotational motion.

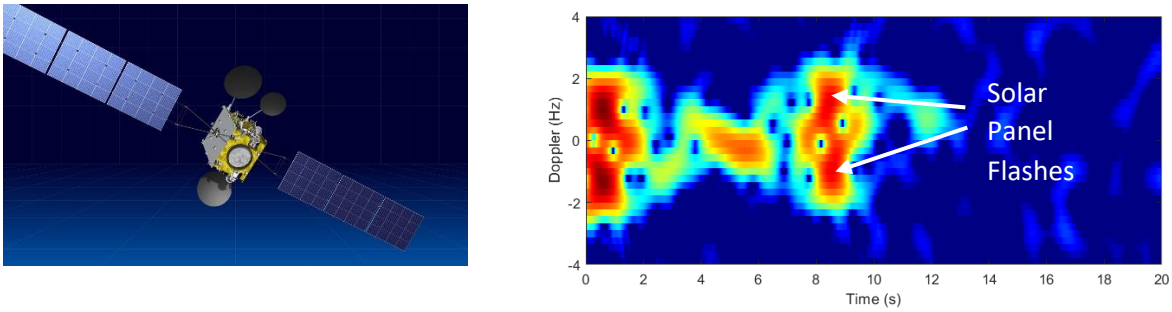

Figure 1 Telkom 3 model[4] (left) and spectrogram using VHF radar data (right).

References

[1] NASA Office of Inspector General Office of Audits, "NASA's efforts to mitigate the risks exposed by orbital debris,"NASA, Tech. Rep. 1G-21-011, 2021.

[2] A. Boley and M. Byers, "Satellite mega-constellations create risks in Low Earth Orbit, theh atmosphere and on Earth," Scientific Reports 11, Tech. Rep. 10642, 2021.

[3] D. Holdsworth, A. Spargo, I. Reid and C. Adami, "Low Earth Orbit object observations using the Buckland Park VHF radar," Radio Science, vol. 55, no. 2, 2020.

[4] J. A. M. Reshetnev, information satellite systems,"http://www.iss-reshetnev.com/spacecraft/spacecraft-communications/telkom-3