Sunset at the Australia Telescope Compact Array, Narrabri, New South Wales

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“Commensal” Space Domain Awareness with ATCA

Space Domain Awareness (SDA) is the necessary pursuit of monitoring the movement of artificial satellites and debris in near-Earth space to ensure data downlink and prevent debris-forming collisions.

This becomes more important as reliance on services provided by space-based infrastructure grows, including location and navigation, weather and natural disaster forecasting, and telecommunications.

SDA is performed by large, geographically distributed networks of specialised sensors and high-performance data processing systems that attempt to locate each known object in orbit as often as possible.

Timestamped detections are logged to a public catalogue that is then used with complex astrodynamical models to predict the movement of each object in the near future, to assist in future detection and predict potential collisions in time for avoidance maneuvers to be made.

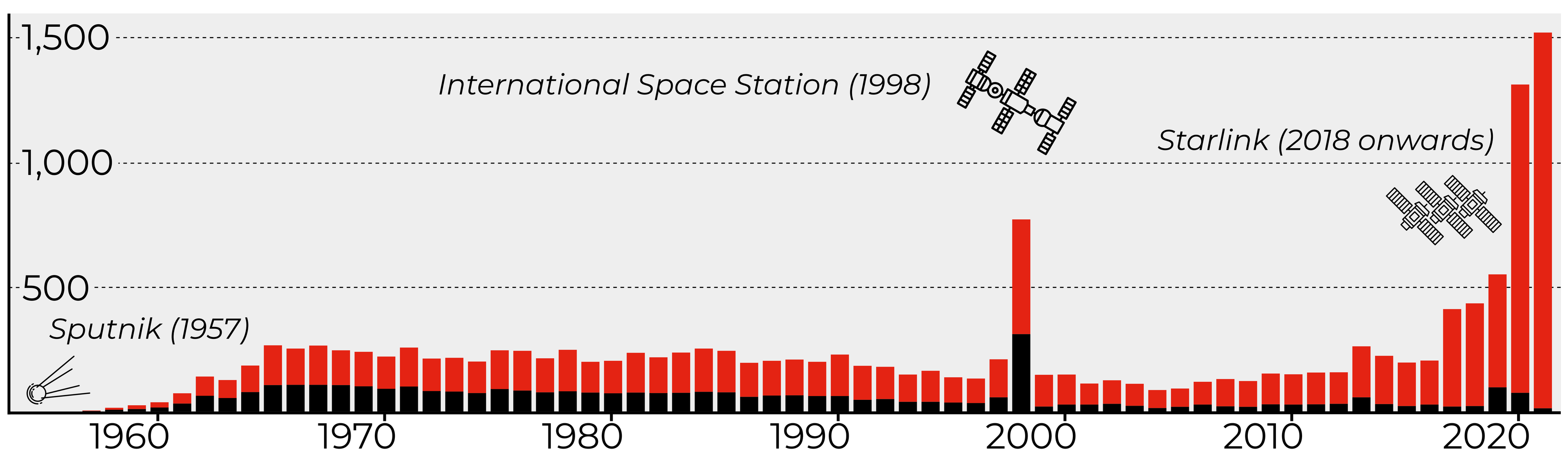

Figure 1. *Number of satellites launched into orbit per year. Objects shown in* ***black*** *have since decayed, while objects shown in* ***red*** *are still in orbit (Celestrak, 2021).*

In recent years, the capacity of dedicated SDA space tracking systems has failed to match orbital population growth. This has led to existing systems for related tasks such as radio astronomy being adapted to act as supplemental SDA sensors (Morreale, et al., 2017).

But the engineering work to adapt a system designed for observing deep space to instead track fast-moving objects in the near field is significant, and limitations often remain in software and hardware.

This has limited the uptake of SDA work in supplemental sensors, as it is difficult to justify the cost of adaptation—let alone the ongoing allocation of time away from the system's regular operation to instead do SDA.

But what if telescopes could do both at once?

“Commensalism” is a term from biology that describes a specific form of symbiosis: a relationship between two organisms in which one party benefits from the other, without the other being affected.

Applied to an SDA context, a commensal system could take data from a telescope or array of telescopes performing regular astronomical observations and perform additional processing to identify satellites or debris as they pass through the beam foreground. Theoretically.

So how can the approach be verified?

The Australia Telescope Compact Array (ATCA) is one of the most sensitive radio sensors in the world, and its high frequency range and low latitude make it highly desirable as a supplemental SDA sensor—it can observe wavelengths and regions of sky that most sensors cannot.

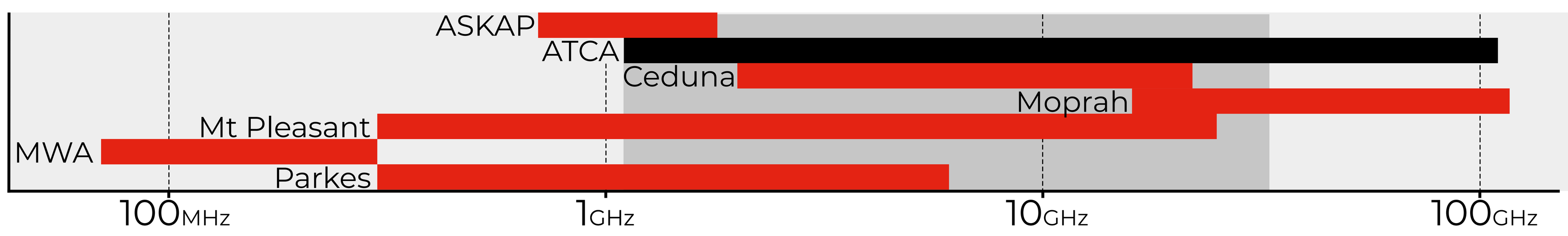

Figure 2. *Approximate observable ranges of key Australian radio telescopes. ATCA is shown in* ***black****, others in* ***red****. Shaded region indicates satellite transmission bands.*

For astronomy alone, requests to observe with ATCA exceed the time available by around 70% (ATNF, 2020). To ensure SDA work doesn't contribute to this problem, a commensal solution is ideal.

But a commensal SDA module cannot just be added to the end of ATCA's existing data processing pipeline; the steps currently undertaken to extract information relevant to observing astronomers differs from that which is required to effectively track near-field objects.

Instead, the module must be installed *within* the ATCA processing backend and given access to raw voltage data *before* it has undergone processing. This will then establish an entirely separate secondary data processing pipeline for SDA-specific outputs.

Unfortunately, though many processing steps will remain the same as the astronomy pipeline, several key algorithms are not applicable when observing either commensally or close to Earth.

Then what needs to change?

Much like a human trying to look at the end of their own nose, ATCA would have to go “cross-eyed” to see Earth-orbiting objects properly.

Lacking that ability, novel algorithms are needed to recognise objects that are detected outside the centre of the observing beam, as well as to reconcile the disparate observations of each ATCA telescope into a single, cohesive output—while maintaining the integrity of key features such as Doppler information therein. Investigation of such is underway.

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