

Space Services with ATCA

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Australia's National Science Agency

Space Services

- Space Situational Awareness (SSA)
 - Space Weather
 - Near Earth Objects
 - Space Surveillance and Tracking
- Satellite Communications
 - RX only
 - Up to deep space
- Characterisation of space objects
 - Radar cross section (RCS)
 - Inverse SAR for tumbling objects
 - Emissions from satellites (intended or unintended)



Space Situational Awareness (SSA)

- Knowledge of the complex space environment.
- To maintain physical access to space.
- Economies are dependant on space assets.
- Diversity of sensors.
- Use of existing capability / sensors.



Image from 'Australian Defence Space Projects ADPC Seminar Series', 10 Oct 2019, WGCDR Steve Henry.

https://airpower.airforce.gov.au/APDC/media/Events-Media/Seminars/SMR49-2019_10_10-Australian-Defence-Space-Projects-Steve-Henry.pdf

History of SSA on ATCA

- Radio telescopes are some of the most sensitive receiving systems available.
- Existing radio telescopes (Sardinia Radio Telescope, Effelsberg Radio Telescope, Murchison Widefield Array) have demonstrated their ability to detect space debris.
- ATCA (Rx) and the Deep Space Network at Tidbinbilla (Tx) are used for bistatic radar observations of near-earth asteroids. This work will also benefit from the upgraded features in BIGCAT.
- Project funded through Space FSP, February 2019 June 2020.
 - Feasibility of SSA on ATCA.
 - Sensitivity, use cases, field of regard calculations, learning about current operations.



Operationalised SSA mode on ATCA?

- Niche SSA service, not competing with dedicated SSA instruments.
- ATCA characteristics of wide frequency range, high sensitivity, extended baseline and precision calibration capabilities are all beneficial for a niche SSA service.
- In parallel with radio astronomy
 - Blocks of time dedicated to SSA (income stream)
 - Target of opportunity slots requested on short notice (income stream)
 - Data collected commensally with radio astronomy observations



Target ATCA SSA Capabilities

- Refine the trajectories of transmitting satellites to a higher accuracy than is available from most other SSA systems – providing updates for 'the catalogue' of orbiting objects.
- Subject to access to a suitable transmitter, do the same for non-transmitting objects.
- Characterise some aspects such as radar cross section of debris and satellites or unintentional transmissions of satellites.



ATCA for Space Services

Timely and accurate information about the space environment through

- Interferometry for near-field objects
- Tracking objects with quick movement
- Modeling unknown movements
- Characterising shape of objects
- Demodulating voltages

Range of space data products

- Location
- Velocity
- Range
- Radar Cross-section (RCS)
- Payload



Direction-Finding using Visibilities

Output of the GPU-based correlator can be used to localise space objects





Direction-Finding using Visibilities

Benefits

- Compliant (almost) with radio astronomy operation
- Takes advantage of radio astronomy calibration procedures
- Reduced amount of data compared to storing the voltages

Requirements

- Ability to have short cycles (order of µsecs and msecs) without losing spectral resolution
- Ability to adjust pointing for near-field region
- Ability to apply fringe rotation for sources in nearfield region (Nice to have!)



Providing a Range of Data Products using Voltages

- Time difference of arrival (TDOA) as well as direction of arrival (DOA)
- High resolution doppler frequency
- Range (Bistatic RADAR)
- RCS



** Diagram Includes drawings from BIGCAT Overview (v0.524February2021), Chris Philips

Providing a Range of Data Products using Voltages

Benefits

- Ability to provide a broad range of parameters
- Ability to deploy bespoke software across GPUs

Requirements

- Voltages stored for all antennas
- Convenient and practical code deployment



Commensal Radio Astronomy and Space Services

Having a few dedicated GPU clusters for space services will allow the two services to coexist





** Diagram Includes drawings from BIGCAT Overview (v0.524February2021), Chris Philips

Commensal Radio Astronomy and Space Services

Benefits

- Independent space services operation
- Continuous RFI data

Requirements

• Having extra GPU clusters to process a subset of coarse channels



Direction-Finding using Visibilities Initial Results

Tracking Sky Muster 2- November 2020

- K-band
- Array configuration: 6B
- Correlator configuration: cfb_64_32_2f_zm16







Thank you

Astronomy and Space Science

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