Mitigations for radio astronomy

Telescope Boresight Avoidance and Operational Data Sharing

Federico Di Vruno, SKAO Spectrum Manager

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With contributions from:
US National Radio Astronomy Observatory (NRAO)
Committee on Radio Astronomy Frequencies (CRAF)

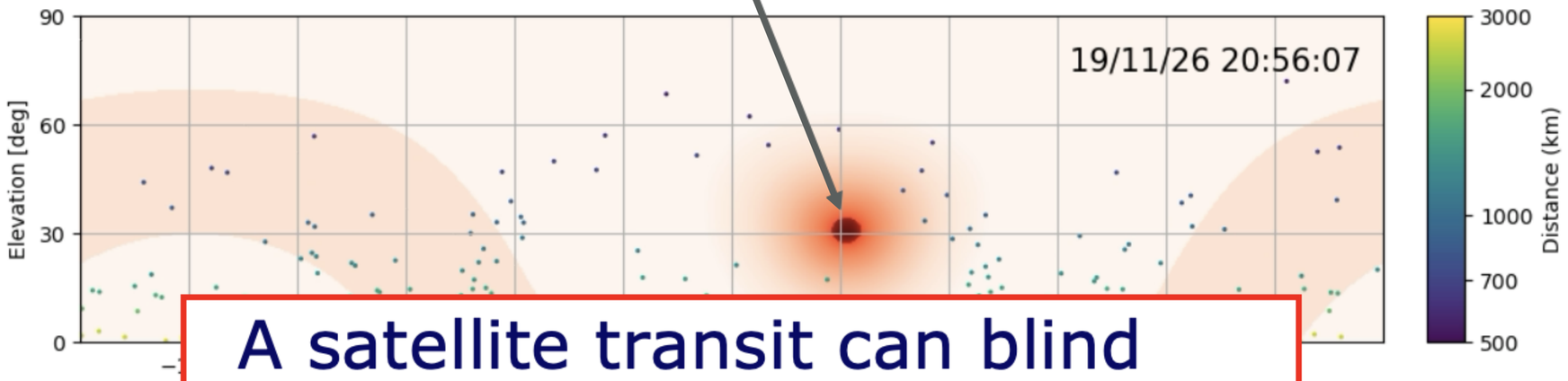
Dark and Quiet Skies

Effects of Satellite Constellations:

- Intentional radio emissions (downlinks)

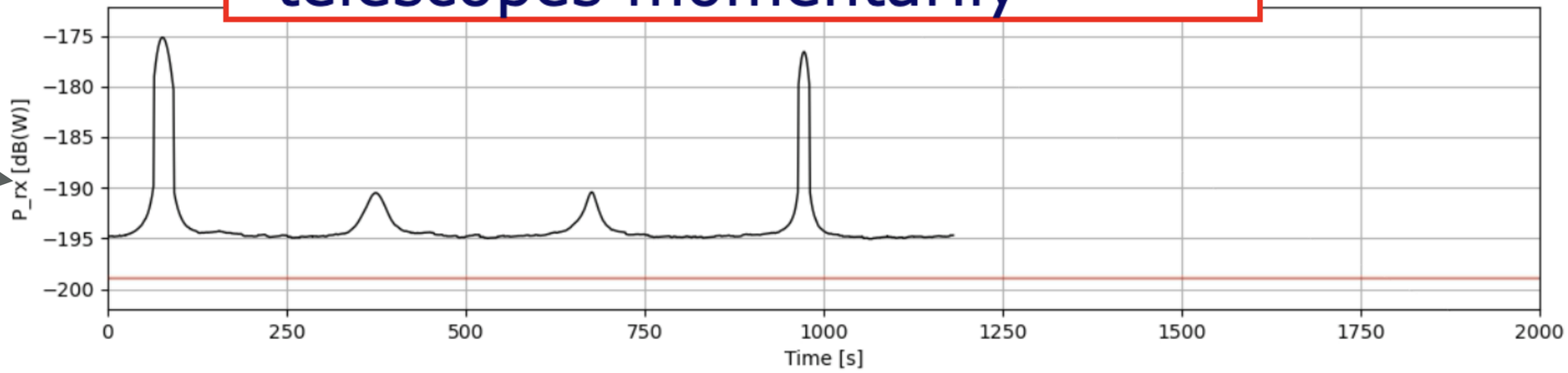
Strong signals into telescopes

Telescope pointing



A satellite transit can blind telescopes momentarily

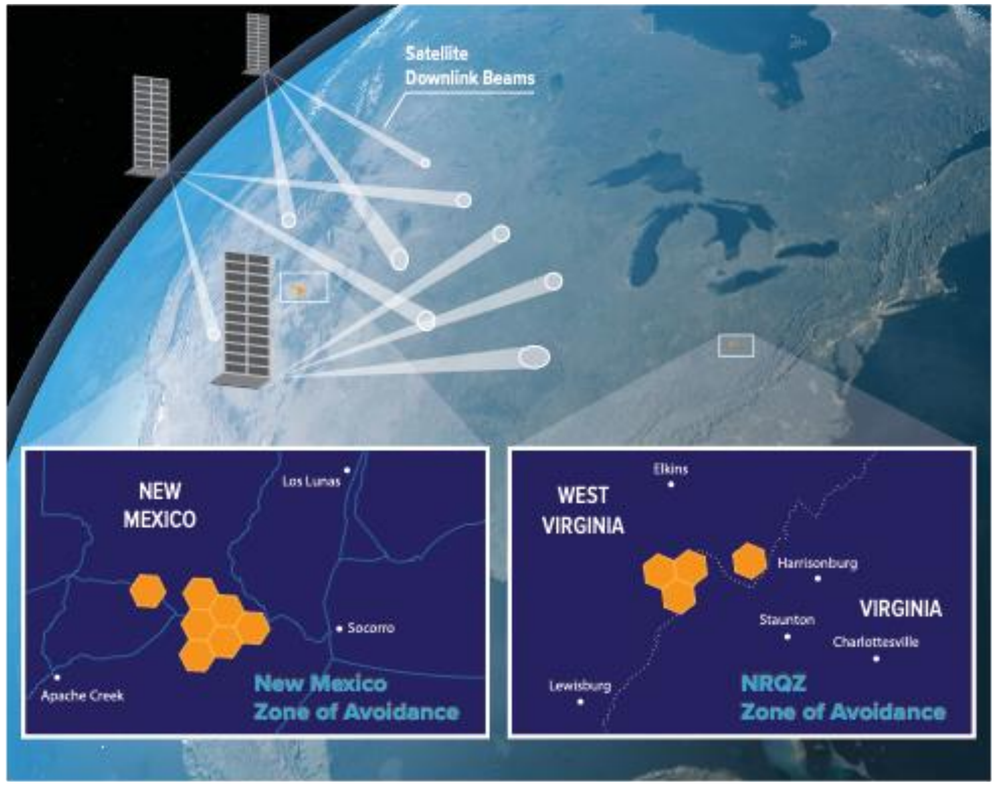
Received power

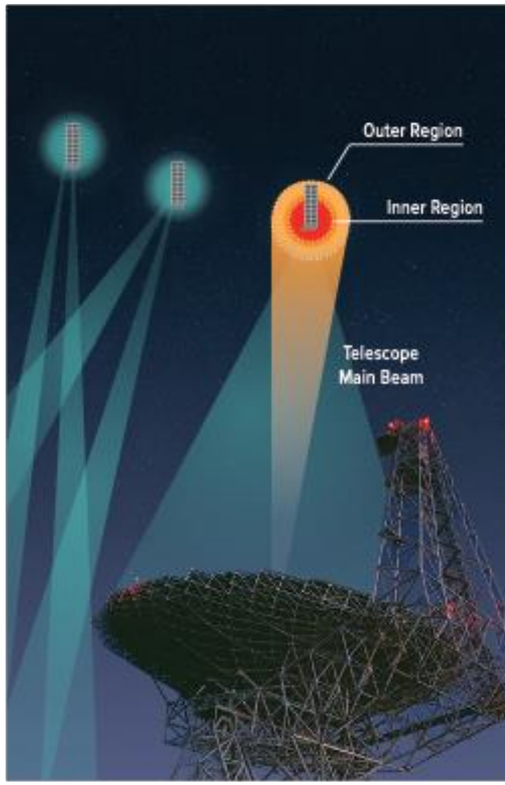


Credit: Benjamin Winkel – Committee on Radio Astronomy Frequencies (CRAF)

Possible mitigation strategies

- Zone Avoidance (ZA)
- Frequency sharing (downlink at bands not used by telescopes)
- Operational Data Sharing (ODS)/Telescope Boresight Avoidance (TBA)
- Conditions in national service licenses or launch licenses (Example: US NSF coordination agreements)

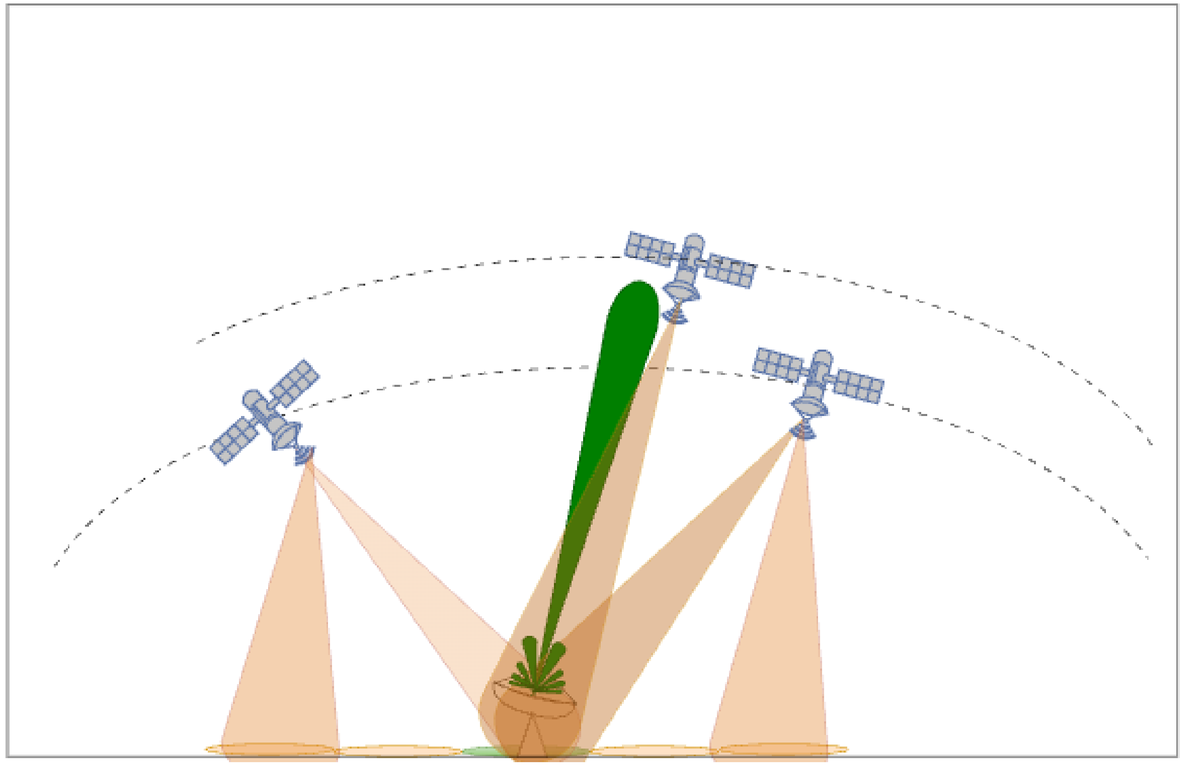




Zone Avoidance implemented by Starlink in the Very Large Array (VLA) and in the US National Radio Quiet Zone

Telescope Boresight Avoidance (TBA)

- Satellite constellation to divert beams away from the radio telescope, especially when close to its pointing direction (**boresight**)
- If a satellite passes through (**transits**) the telescope beam, momentarily stops transmissions
- Can be implemented on a “per channel basis”
- Requires information sharing between telescope – satellite constellation



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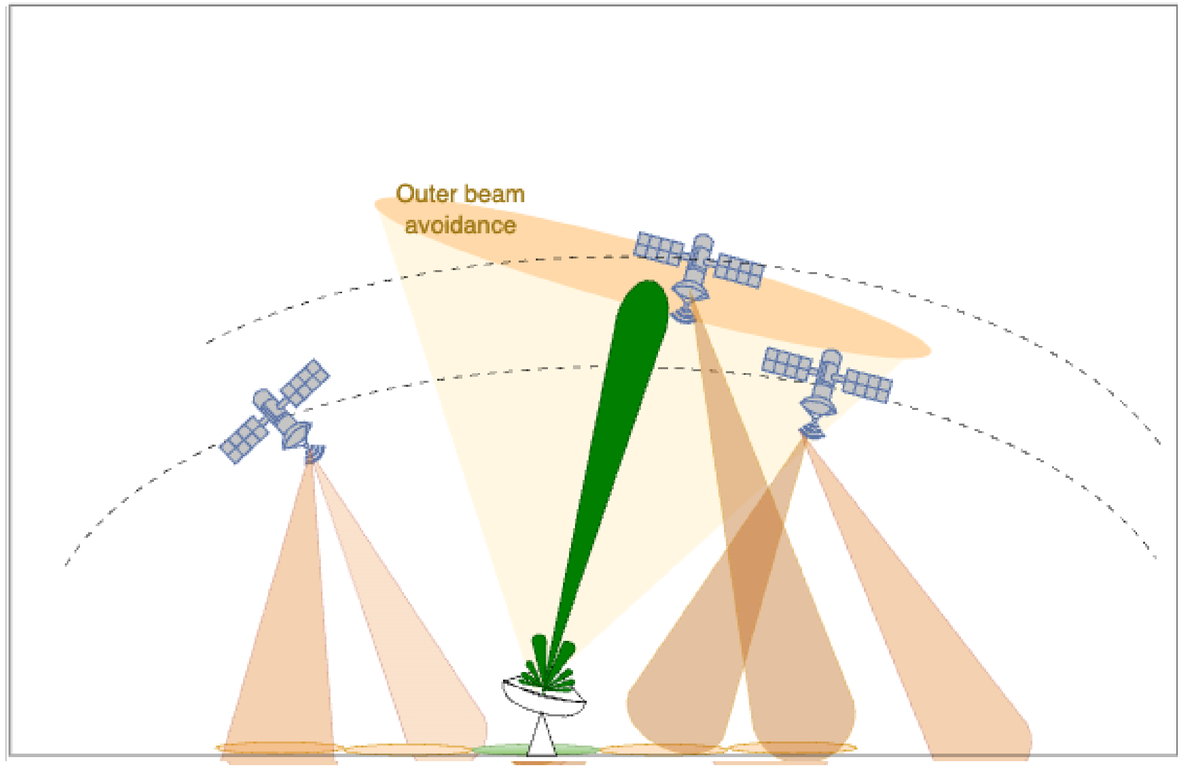

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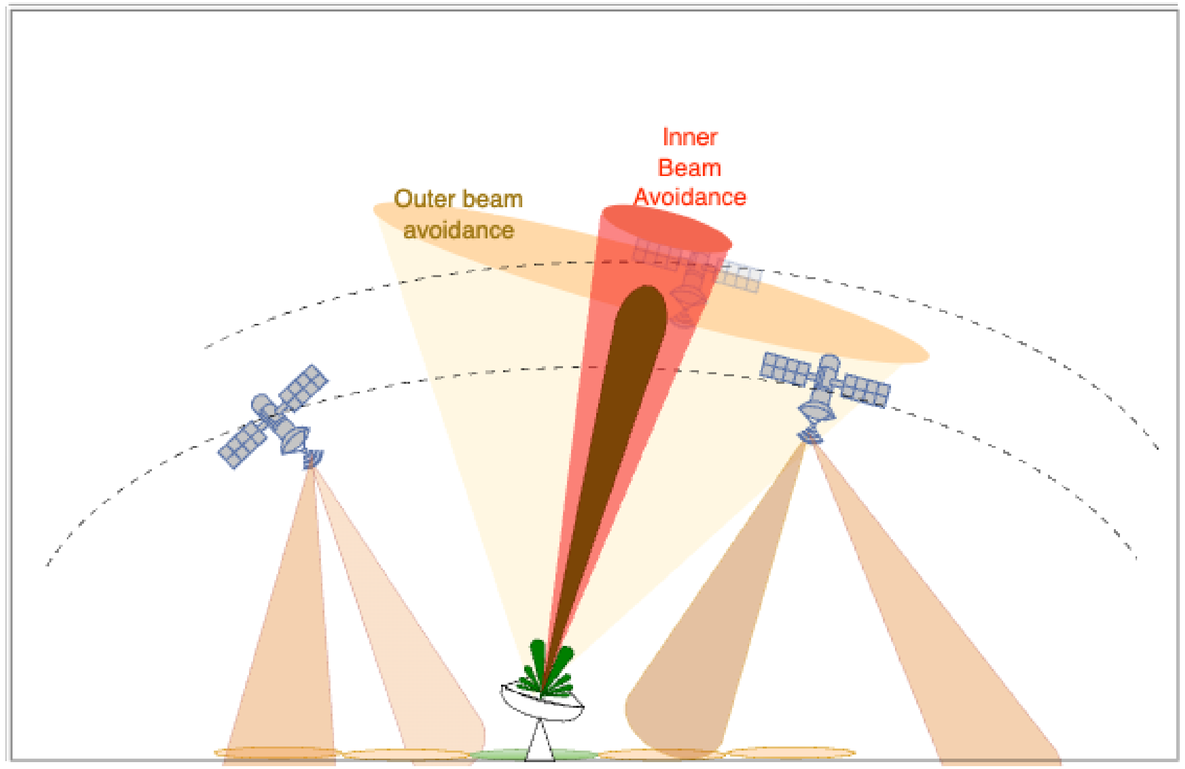
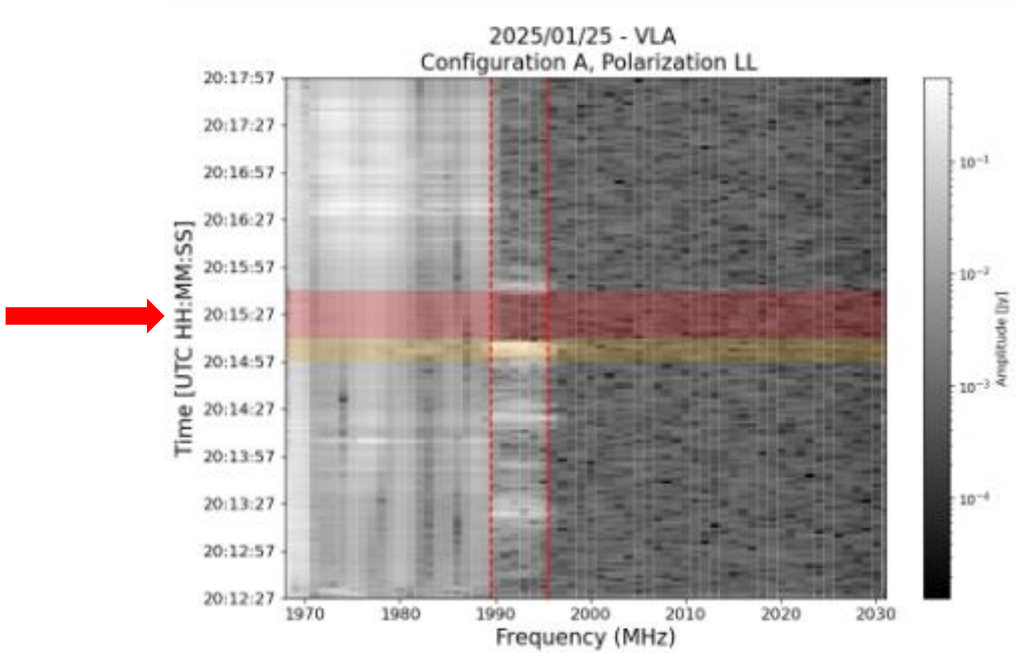
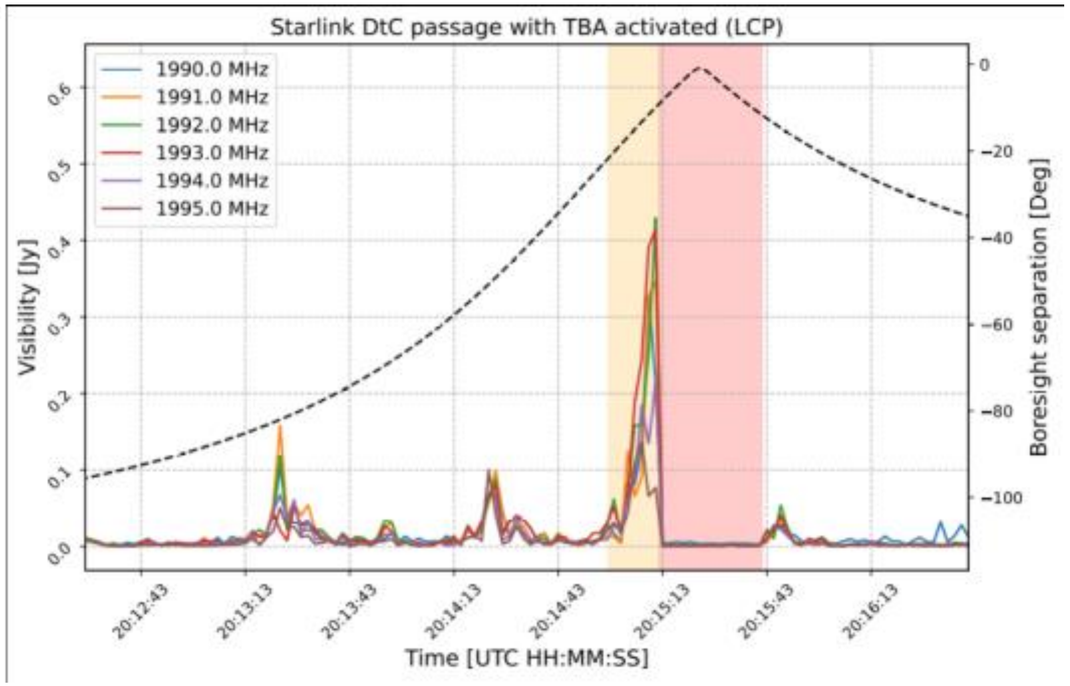


TBA implemented in USA

Very Large Array (VLA, New Mexico)
Direct to Device (1990-1995 MHz)



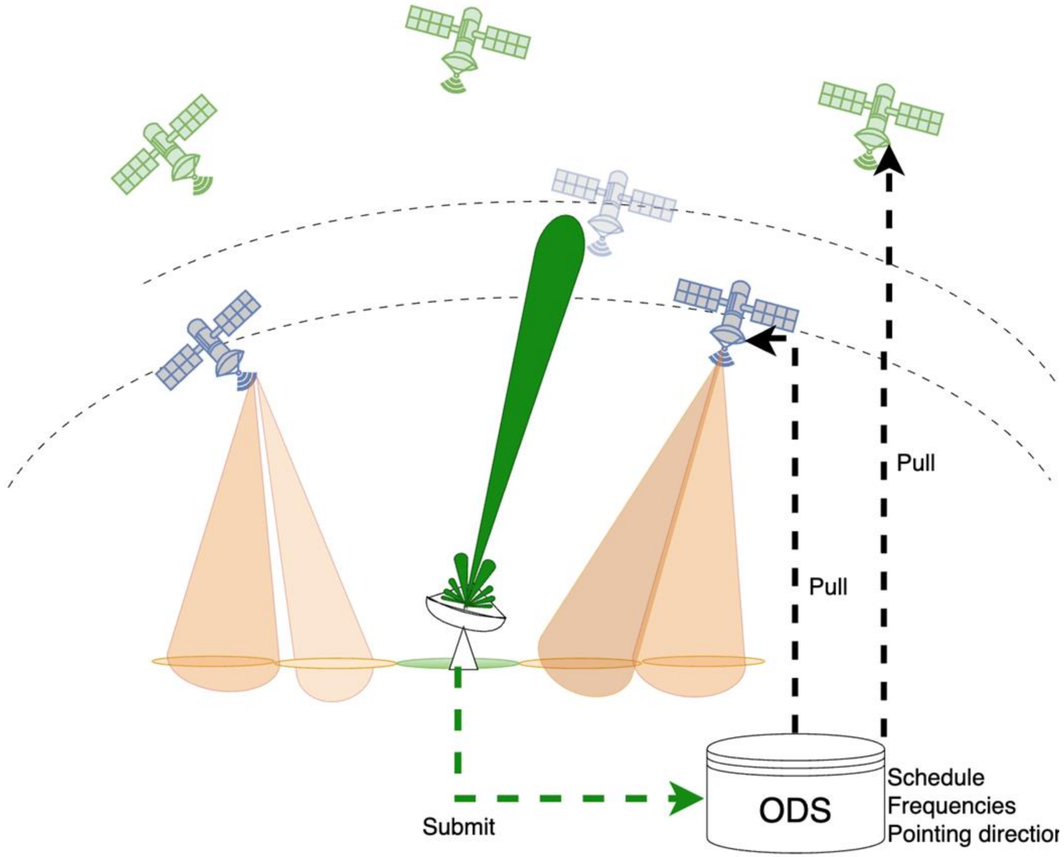


Orange = Outer TBA (Steer beams away)
Red = Inner TBA (Disable downlink)

Nhan, et al. (2025), *IEEE Communication Magazine,*
https://arxiv.org/abs/2502.15068

Operational Data Sharing (ODS)

- Communication Telescope – satellite constellation, developed by US NRAO
- Database regularly updated with telescope schedule
- Multiple operators can pull data from it
- Enhancing security for data access by satellite operators
- Implemented in: USA, Australia, SKAO (planned)



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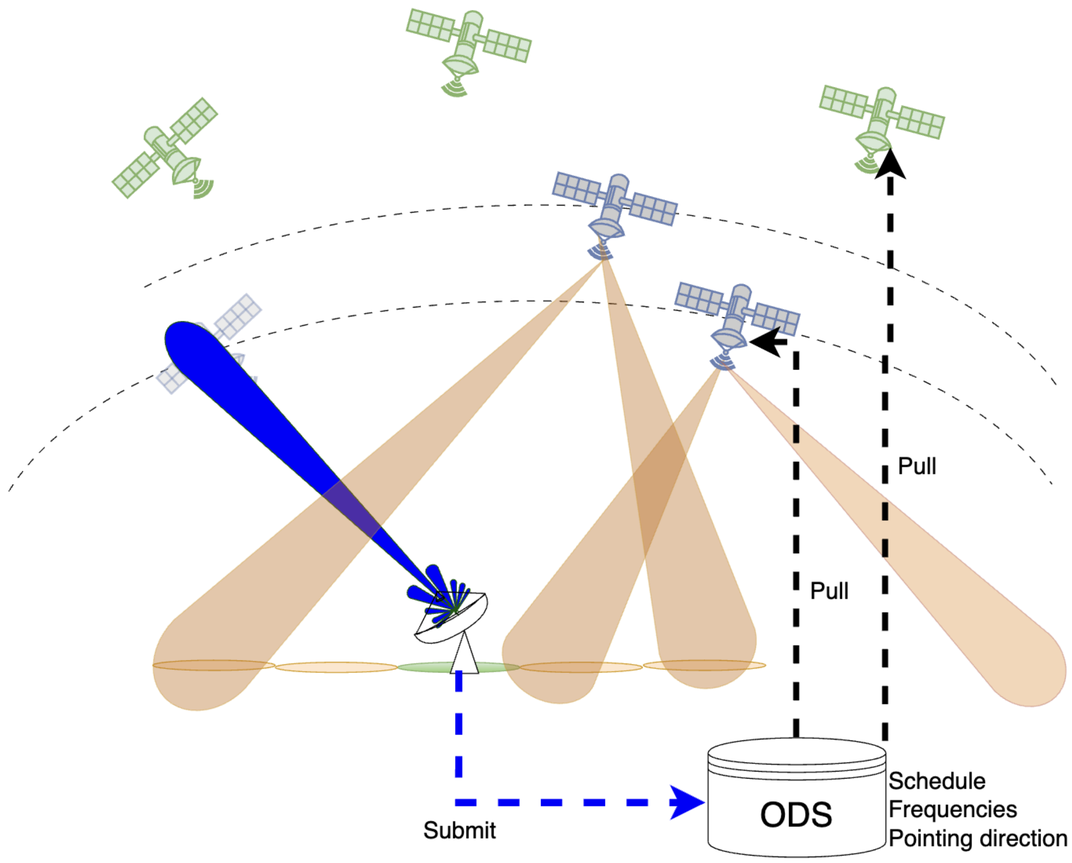


Summary

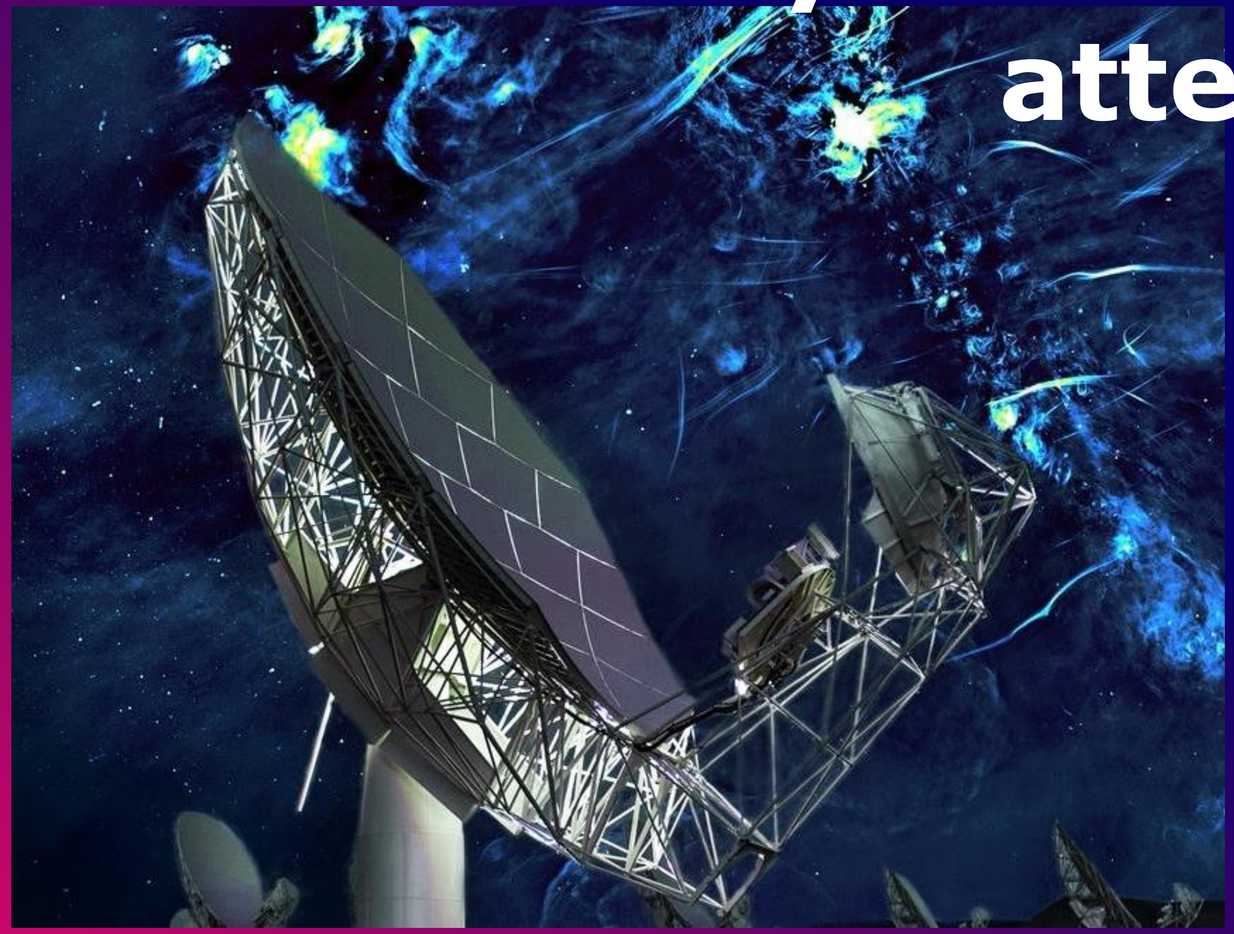
- Telescope Boresight Avoidance (TBA) can minimize very high received power into radio telescopes, avoiding saturation (blinding) of receivers

- Operational Data Sharing (ODS) allows for sharing information about the telescope operations for satellite operators to implement TBA.

- More information on frequencies/position of satellites could assist in enhancing data processing methods for radio astronomy observations

- Caveats:
- TBA can only be implemented by satellites with electronically steerable beams.
- TBA will have some impact on available service of the satellite constellation, as a function of number of satellites available to choose from.

Thank you very much for your attention



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We recognise and acknowledge the Indigenous peoples and cultures that have traditionally lived on the lands on which our facilities are located.

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