

# Observing around low earth orbit satellites: threats and possible solutions at radio frequencies

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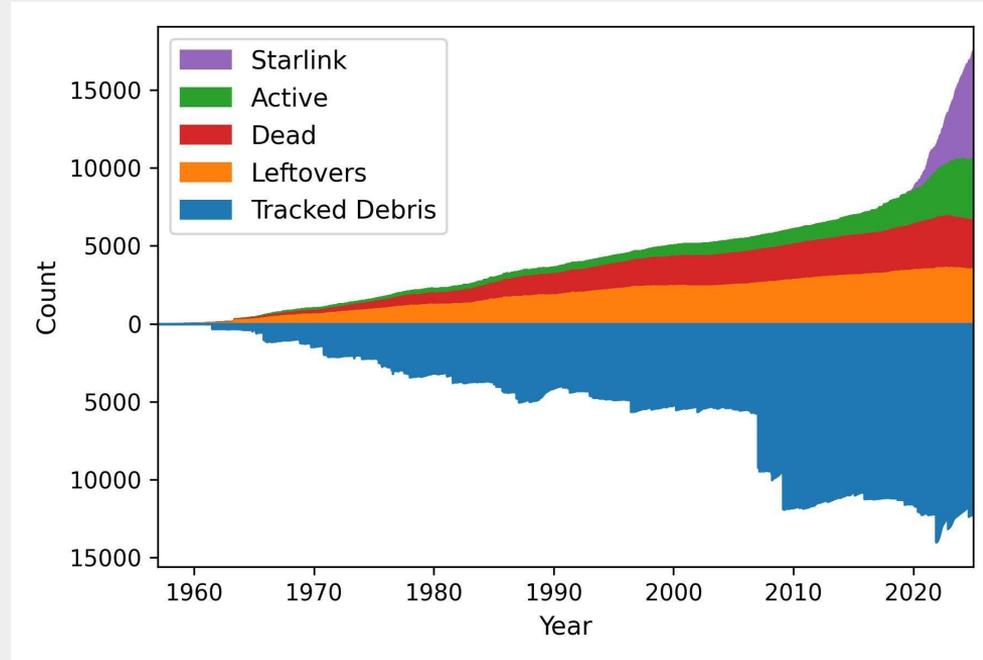
ATNF Futures 2030 Workshop, 18 February 2026





# Space is changing very rapidly

- ~14,000+ satellites in Low Earth Orbit
- ITU filings for >1,500,000 satellites  
+ 1 million SpaceX AI data centres  
+ more continually...
- Major concerns:
  - Effects on optical astronomy
  - **Effects on radio astronomy**
  - Effects on the night sky
  - Space traffic management
  - Space debris



# How do satellites affect astronomy?

\*Not to scale - for illustration purposes only

## Reflecting sunlight

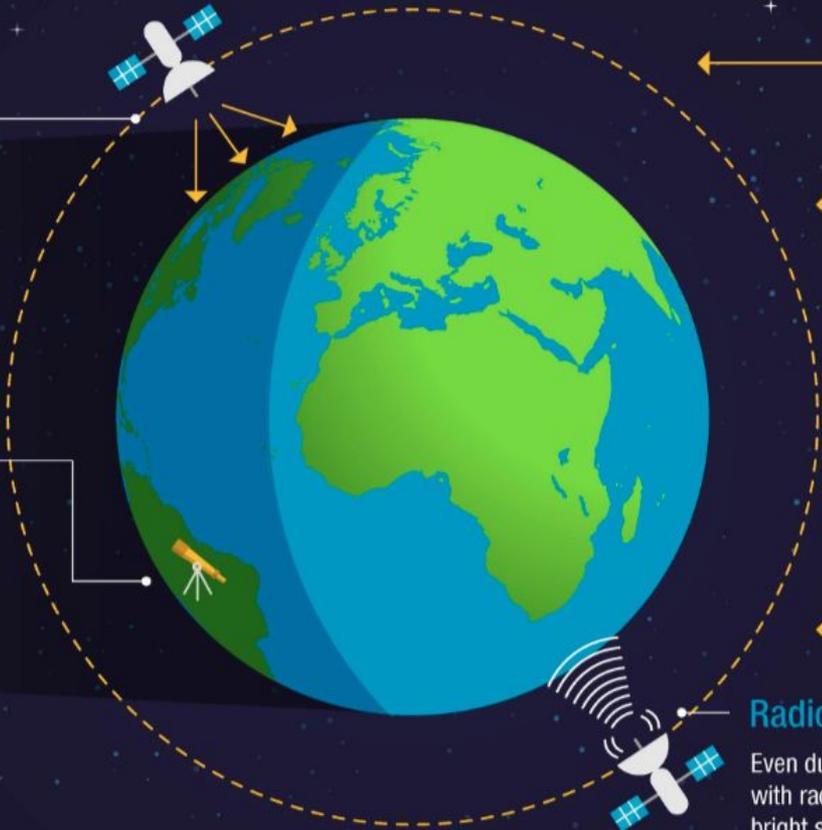
Because of their altitude, satellites can reflect sunlight down to locations on Earth where the Sun has already set – when optical telescopes are observing. How bright these reflections are depends on the satellites' orientation, size, material and reflectivity.

## Changing the night sky

Casual stargazers, astrophotographers, and Indigenous communities that have observed the night sky for generations are seeing increasing numbers of satellites, altering their view of pristine night skies.

## Radio emissions

Even during the day, satellites can interfere with radio telescopes on Earth due to the very bright signals they emit to transmit information, but also due to unintended electromagnetic radiation leaking from their onboard electronics.





# IAU Centre for the Protection of Dark and Quiet Sky

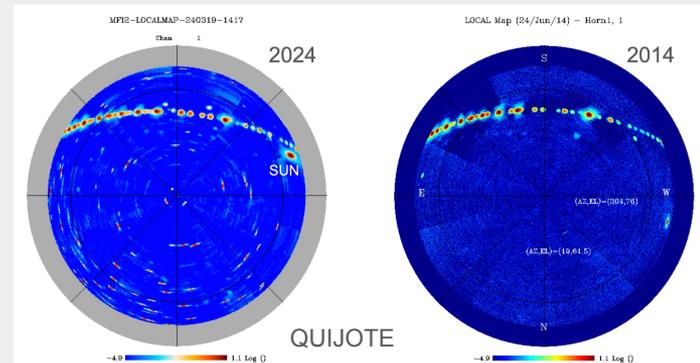
Coordinate efforts and unify voices across the global astronomical community to protect the dark and quiet sky from satellite constellation interference. **Four hubs:**

- **SatHub:** Assess constellation impact on optical and radio astronomy via independent **observation campaigns** and **peer reviewed publications**, and **develop mitigation tools** for astronomers / observatories (SatChecker, SCORE, etc.)
- **Industry & Technology Hub:** Foster collaboration between the astronomy and satellite operator communities
- **Policy Hub:** Studies national and international policies and regulations related to the use of space
- **Community & Engagement Hub:** Bridge between all involved stakeholders and affected communities



# Impacts at radio frequencies

- Active high frequency transmissions: **10-20GHz** now, 40GHz, 120-180GHz soon?
- New: direct-to-cell/device active transmissions at **1.4-2.7GHz** now being rolled out (AST, SpaceX, etc.) (also many GPS satellites around ~1.2GHz)
- Also unintended emissions (see **Balt's talk!**) - mostly ~100MHz, but up to ~GHz and beyond
- Out-of-band emission and telescope sidelobe coupling also of concern
- Satellites are highly variable - need to accurately know positions, or see them as transients?
- Protected radio bands very narrow - observations normally use broader unprotected bandwidths



QUIJOTE 10-14GHz observations from Tenerife in 2014 and 2024



# Ways to avoid observing satellites

- **Know telescope positions, avoid transmissions towards them**
- Using remote sites no longer sufficient to avoid transmissions. Radio quiet zones only apply to ground-based transmissions (and are nationally defined, not internationally/recognised by ITU).
- Can ask satellite operators to avoid sites - SpaceX do this (using phased arrays), others don't (fixed dish transmissions). Based on national requirements. (Australia doesn't seem to do this at all?)
- Operational Data Sharing for boresight avoidance. Share telescope pointing positions in advance, satellites turn off when passing through beam. See <https://arxiv.org/abs/2407.21675> - by NRAO, restricted right now but plans to open this up to the community.
- Very important to keep ITU (and national) filings up-to-date (all telescope positions, all frequencies in use)!
- **Or: Know satellite positions and avoid pointing telescopes towards them...**



<https://starlink.com/map>



# SatChecker

- API for predicting satellite positions and transits
- Single satellite or field of view (FOV) predictions
- Define RA/Dec center, radius, and time window, get all satellites overhead at a given time/location
- Access to all archival TLE data (aiming for all TLEs back to 1959) + hopefully more precise positions
- Provides satellite metadata: NORAD ID, COSPAR ID, launch/decay dates, etc.
- API docs:  
<https://satchecker.readthedocs.io/en/latest/>  
<https://satchecker.cps.iau.org/api/docs/>
- Also SCORE: Satellite Constellation Observation Repository - but more aimed at optical observations right now (see <https://score.cps.iau.org/> )

The screenshot shows the SatChecker website navigation menu. At the top is the SatChecker logo and a search bar. Below are several categories: EPHEMERIS API (with sub-items: Ephemeris API, API Response Details, Error Codes, Notes), TOOLS API (with sub-items: Satellite Information, TLE Data Access), FOV API (with sub-item: Field of View (FOV) Endpoints), EXAMPLES (with sub-items: API Examples, Example Notebook, Field of View Visualization Notebook, Satellites Overhead Visualization Notebook), and DEVELOPMENT DOCUMENTATION (with sub-items: src.api package, Release History, Acknowledgements).

🏠 / SatChecker Ephemeris API Documentation [View page source](#)

## SatChecker Ephemeris API Documentation

### Overview

SatChecker is a satellite position prediction tool from the IAU CPS (IAU Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference) SatHub group. It uses TLEs (two-line element sets) from CeresTrak and Space-Track to provide predictions of satellite positions at a given time and location. It also provides additional information like range, on-sky velocity, and an "illuminated" flag for each prediction point.

SatChecker uses the TLE with the closest epoch date available to the date specified in the API parameters - currently available TLEs go back to July 2019. General TLE data is updated daily, and supplemental TLEs from CeresTrak are updated every 8 hours.

The SatChecker Tools API provides additional functionality for satellite name and ID lookup, as well as the ability to retrieve all available TLE data for a given satellite over a given date range. Satellites can be assigned temporary IDs after launch, and names are subject to change, so the Tools API can be used to keep track of these changes.

### Support

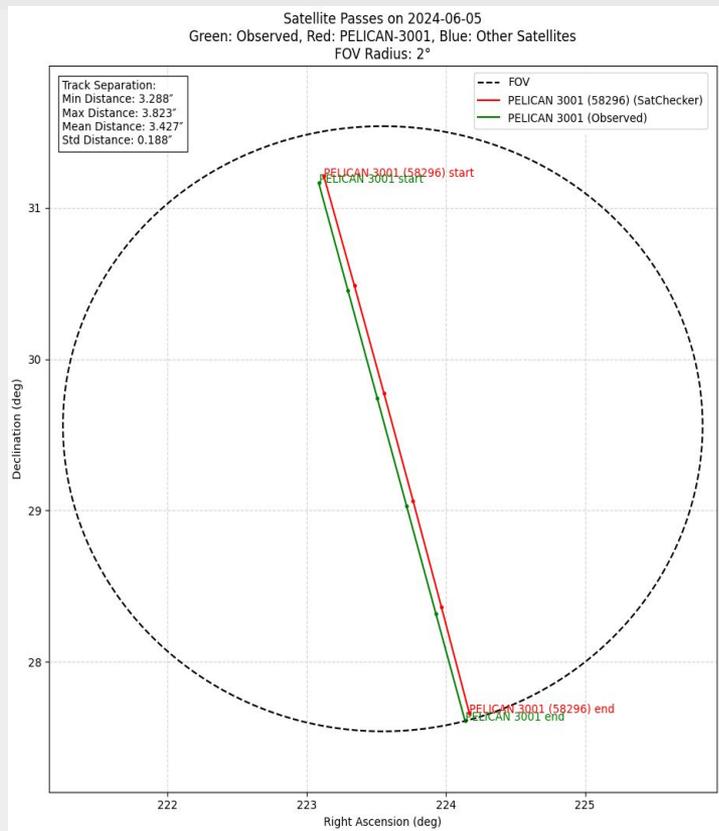


For assistance with SatChecker, please open an issue on the [GitHub](#)

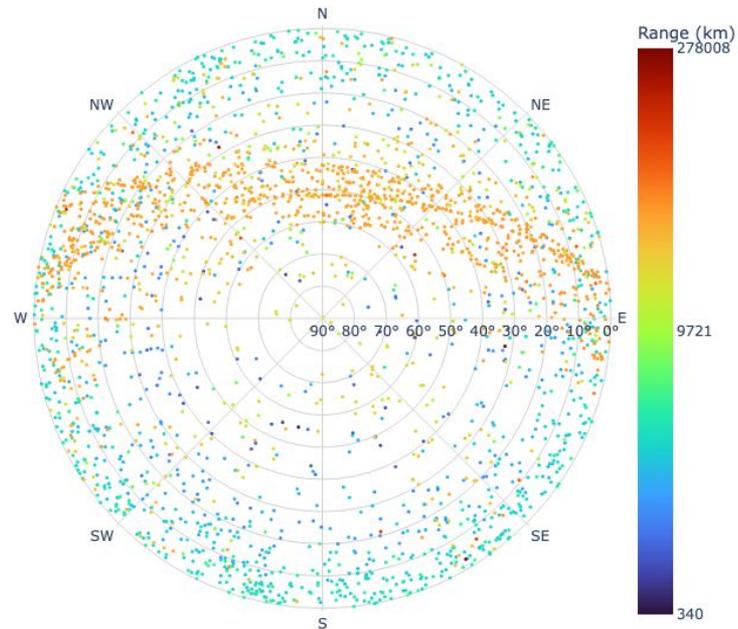




# SatChecker Field of View service



All-Sky View with Alt/Az Grid





# SatChecker + Rubin observations



From Jangid et al. poster at  
Rubin Community Forum

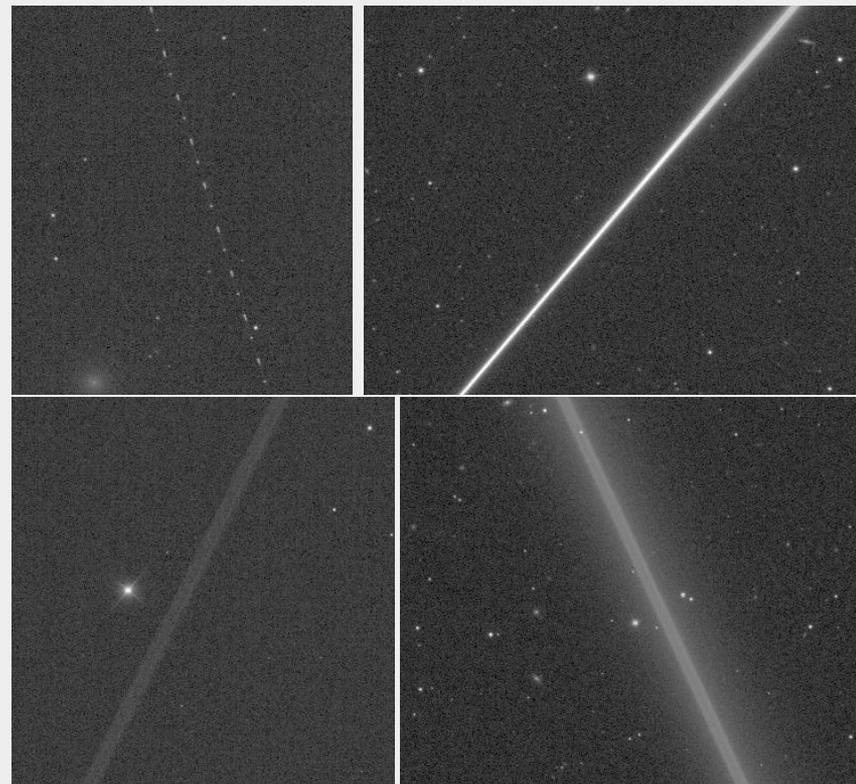
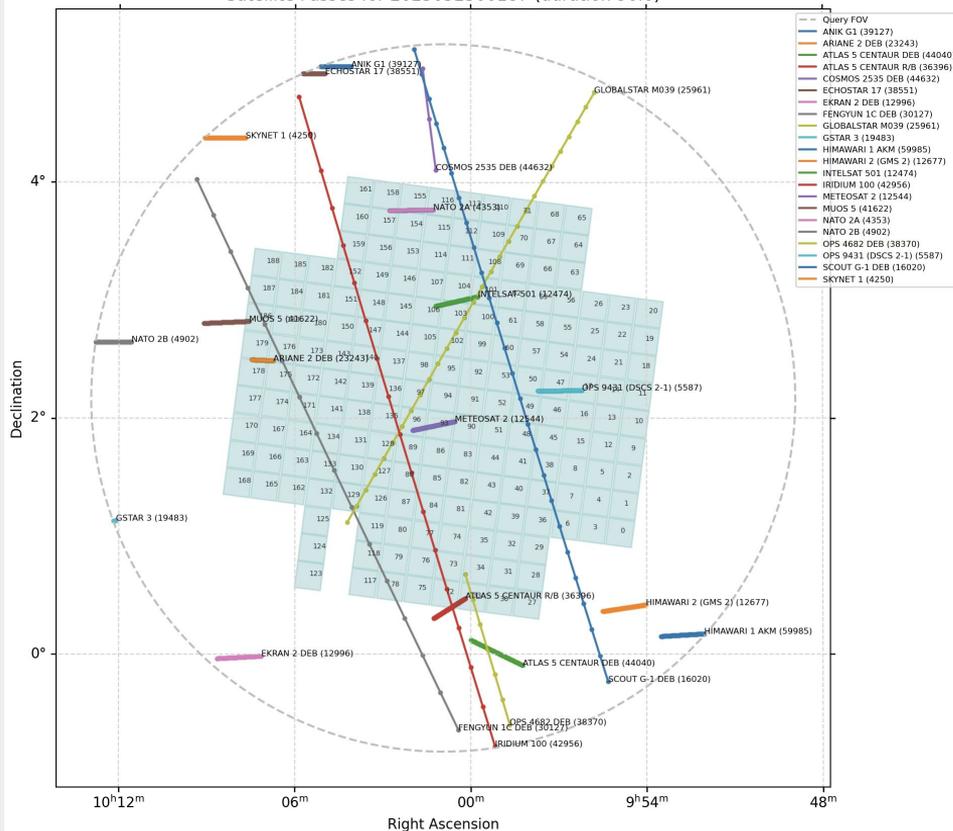


U.S. National  
Science Foundation



Office of Science

Satellite Passes for 2025052300187 (duration 90.0)



<https://community.lsst.org/vrrb-satellite-constellations-and-lsst-new-tools-and-impact-assessments/10729>





# The future for ASKAP with satellites

- **The future is going to be radio-bright** - need to plan for that.
- Ensuring accurate ITU filings is increasingly important.
- Design **capacity to cope** with high out-of-band power entering the system (high IP3 amps, high linearity range in back ends)
- Digital back-ends need capacity to reject more in-band signals
- **ASKAP can help**: Knowing positions of satellites and avoiding them important (interferometers can provide more accurate satellite positions using reflections/transmissions) - Welch et al. 2025, DOI: 10.14339/STO-SET-SCI-297-3
- **Publish** detections/statistics of satellites - helps policy discussions!
- **Simulate** the impact that satellites will have on your upcoming surveys - and publish quantitative analyses - again helps policy discussions!
- **The earlier radio surveys are done, the better**: numbers of satellites and use of bandwidth will only go up over time!





Thanks for listening!

Questions?

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Join CPS!

<https://cps.iau.org>



SKAO

