

The IAU CPS: Satellite constellation impacts, observation campaigns, and software tools

Mike Peel, on behalf of CPS and SatHub
(Postdoc, Imperial College London)

Swiss SKA Days
3 September 2024





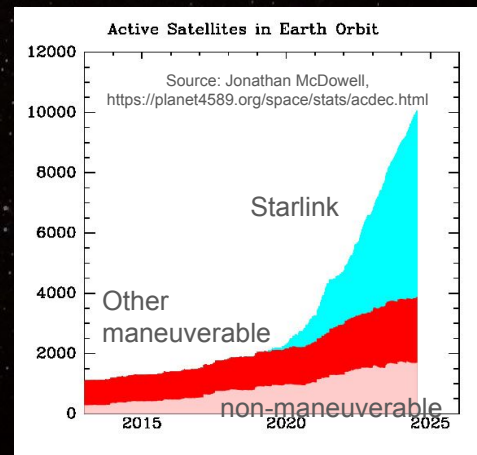
The IAU response to the proliferation of satellites

Promoting guidelines and regulations at the UN COPUOS level

Creation of the “IAU Centre for the Protection of the Dark and Quiet Skies from Satellite Constellation Interference (IAU CPS)”

Led by SKAO and NSF’s NOIRLab:
Director Piero Benvenuti,
Co-directors: Connie Walker & Federico Di Vruno.

CPS organizes the energy of ~350 members and the cooperation of industry through four Hubs.



SatHub: Mitigations on the Astronomy side

Satellite observation and data analysis hub of IAU CPS

- Open source **software development and data repositories**, with substantial contributions from NOIRLab, SKAO, and others
- Volunteer-led **observations and research projects** on satellite constellation interference and mitigation **across the electromagnetic spectrum**
- A collaboration among pro astronomers, experienced amateurs, policymakers, industry experts, satellite operators, and more



Astronomical Data Repositories	Orbital Solution Portal	Software Tools	Training Curriculum	Real-Time Collaboration
				

Community Engagement Hub: Raising Awareness

Leads: John Barentine, Jessica Heim

IAU CPS' bridge to the community of night sky users beyond professional astronomers.



Our Charge and Objectives

We ensures all stakeholders' voices are part of the broader discussion.



Objective 1

Create a venue in which all stakeholders may be heard and feel safe expressing their opinions and views

Objective 2

Manage that venue in a way that fosters respectful dialog among participants to promote the understanding of different and potentially opposing viewpoints

Objective 3

Over time, amass a set of stakeholder opinions as primary sources that we compare critically to find common themes

Objective 4

Use the materials, and the conclusions we draw from them, to inform the activities of the other CPS hubs and our communications with the public on relevant issues



Industry and Technology Hub: Mitigations for Satellites

Leads: Chris Hofer, Tim Stevenson, advisor Patricia Cooper

IAU CPS' arm to engage the technical insights of both satellite stakeholders and astronomers to build the tools and resources to spur voluntary adoption of mitigations

ENLIST

- **Recruit** satellite constellation operators, manufacturers, other stakeholders to participate and collaborate in the Hub to **develop and adopt solutions**

INFORM

- **Provide a flow of references** to the latest technical concerns, recommendations and best practices, and **identify available tools and resources** to assess and adopt mitigations

EXCHANGE

- **Facilitate dialogue among industry stakeholders** on mitigation techniques and their efficacy, and **promote innovative approaches and tools** that are accessible, affordable and effective

Policy Hub: Best Practices -> Regulations

Leads: Andrew Williams, Richard Green, Aaron Boley

1. **Raise awareness** of astronomy requirements in space policy-making circles
2. **Coordinate policy work** conducted by national societies and observatories
3. **Foster the development of better regulation**, in coordination with national points of contact
4. **Coordinate spectrum management processes**, along with emerging optical-related issues
5. **Identify future threats**

Strategic Outcomes

Astronomy community acts together with aligned messages

We produce policy outputs and contribute to policy change

Industry is aware of the issue and of the solutions

Policy makers are aware of the issue and of the solutions



Establishment of Group of Friends (GoF) of DQS

- UN COPUOS Delegations and Observers:
 - Belgium, Bulgaria, Chile, Colombia, Germany, Italy, Luxembourg, Mexico, New Zealand, Rumania, Slovakia, South Africa, Spain, Switzerland, UK, USA
 - COSPAR, EAS, ESO, IAA, IAU, SKAO
- Aims of the Group of Friends:
 - Promote awareness
 - Support/Review best practices and mitigation suggestions
 - Discuss the overall implications of the adoption of mitigating measures
 - Discuss approaches for coordination between the various stakeholders
- IAU serves as the secretariat and provides astronomy input



The IAU CPS SatHub

IAU CPS SatHub co-leads:



Meredith Rawls
U. Washington



Mike Peel,
Imperial College
London



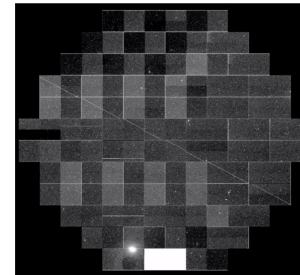
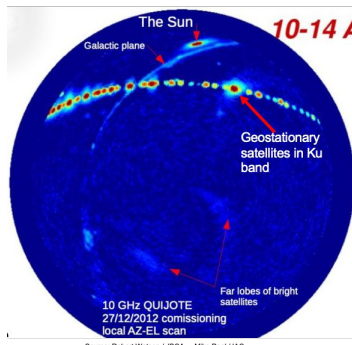
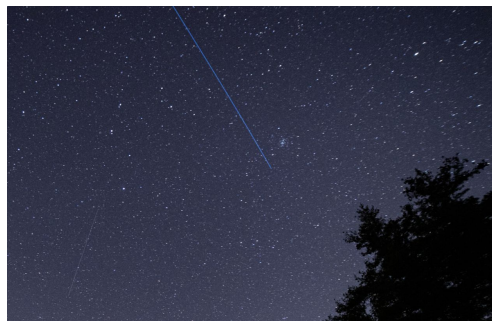
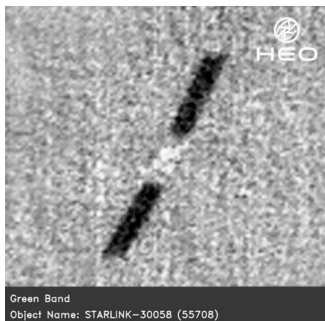
Siegfried Eggli,
U. Illinois





The IAU CPS SatHub

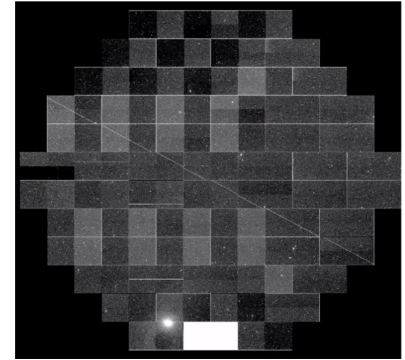
- **Collaborate** among astronomers, experienced amateurs, policymakers, industry experts, satellite operators, government agencies and more.
 - International community with over 200 members.
- **Promote** open source **software development** and curate **data repositories**.
- **Coordinate** observation campaigns to measure satellite brightness and provide feedback to operators and industry **across the electromagnetic spectrum**.
- **Share** technical expertise and develop **recommendations**.





IAU CPS SatHub Aims

- **Assess constellation impact on optical and radio astronomy** via independent observation campaigns and peer reviewed publications
 - Starlink/SpaceX, Kuiper/Amazon, Pelican/Planet Labs, BlueWalker 3/AST Space Mobile, SSST Qianfan, Unintended Radio Emissions/LOFAR, etc.
- **Develop mitigation tools for astronomers/observatories**
 - SatChecker satellite position prediction service
 - Satellite Constellation Observation REpository (SCORE)
 - **NSF SWIFT-Sat: Field-Of-View / active satellite avoidance service**
 - Radio astronomy impact modeling (SCEPTER)
- **Coordinate mitigation efforts** with all stakeholders





How you can get involved!

- **Join:** Apply for SatHub affiliate membership at cps.iau.org, and receive an invitation to our Slack Workspace
- **Contribute:** Develop software at github.com/iausathub, upload observations to SCORE, or pitch a webinar
- **Collaborate:** Use our [#sathub](#) or related Slack channels (preferred), or email sathub@cps.iau.org
- SatHub's success depends strongly on contributions from volunteer members, as well as opportunities for funding.
- **We need your support** to preserve our dark and quiet skies!



Example issues that CPS is working to address

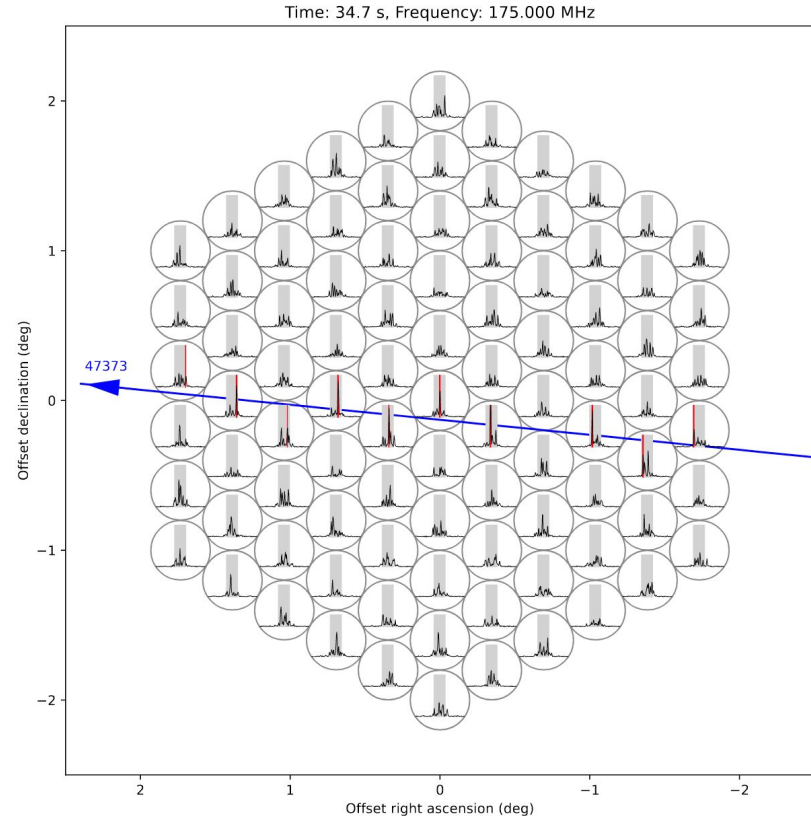
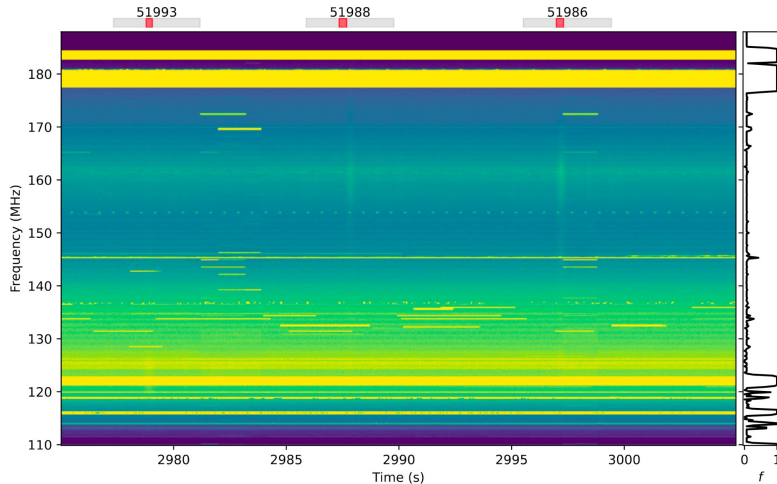
(if not already covered by other talks)





Unintended emission at low frequencies

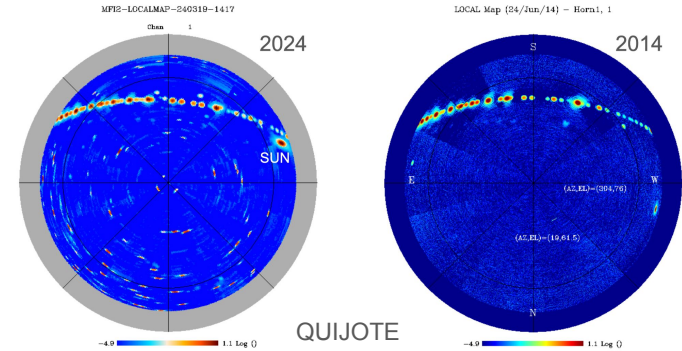
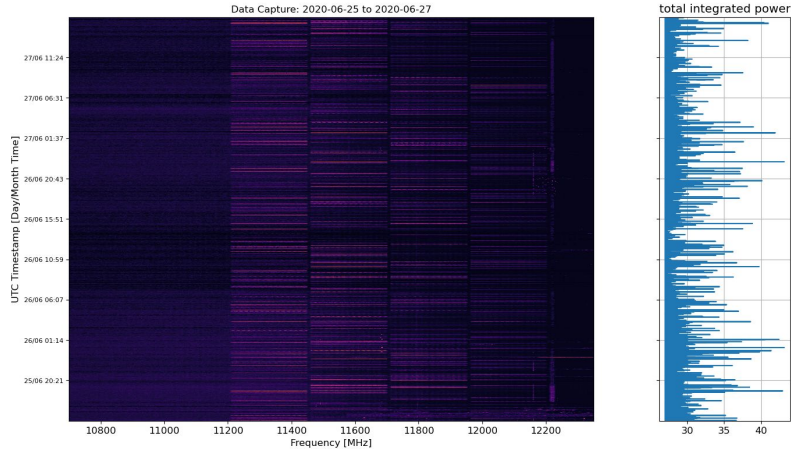
- LOFAR sees Starlink passing overhead!
- Unintended emission from back-end electronics seen at ~150-180MHz
- Not permitted bands for transmitting...
- Di Vruno et al. (2023), A&A (published), arXiv:2307.02316
- (Also Grigg et al., 2023, 2309.15672)





Potential impact at radio frequencies

- We don't know much yet - need observations to assess actual impact
- Active 10-20GHz transmissions - plus 40GHz soon? (and octaves!)
- (Latest Starlink filing of ~30k satellites from Tonga is 120-180GHz!)
- Sidelobe coupling also a concern, particularly for CMB experiments
- Difficult to filter out with broadband detectors, unless using FPGAs
- Highly variable - need to accurately know satellite positions, or see as transients?



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

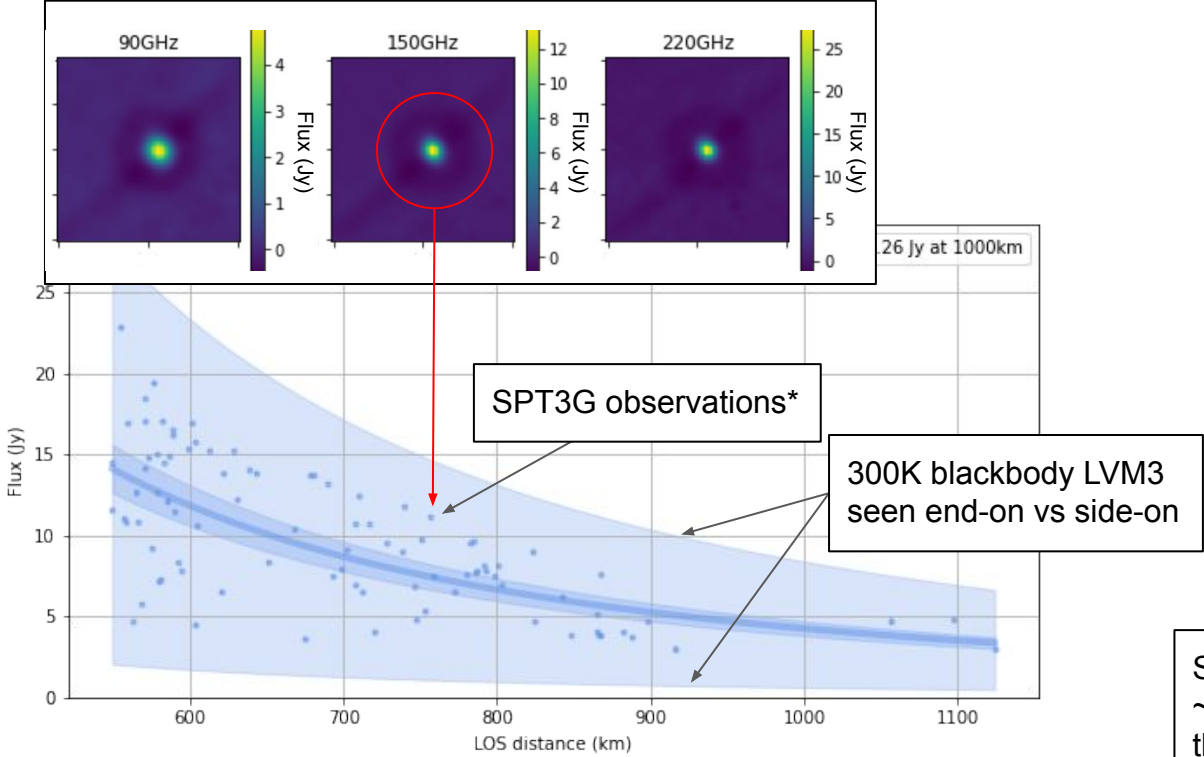
Left: satellite dish observations, F. Di Vruno

PRELIMINARY

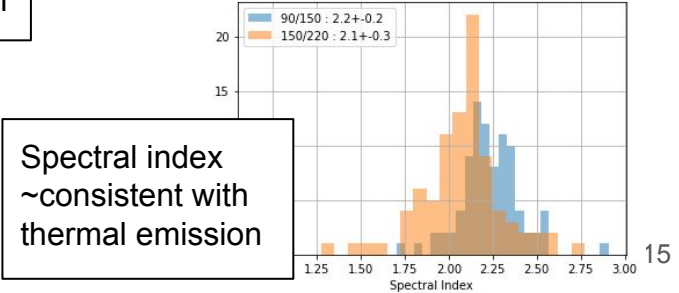
(with thanks to Allen Foster)

Example from SPT3G - Thermal Emission

Even if not actively emitting RF signal, satellites can be millimeter bright!



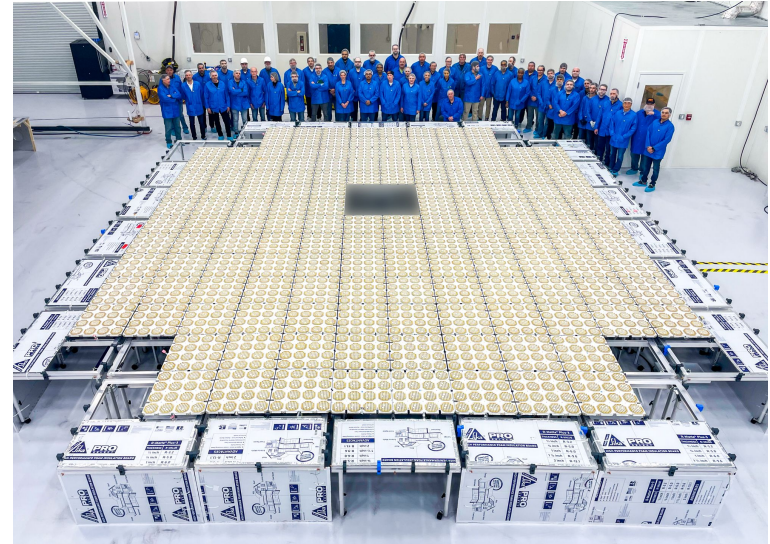
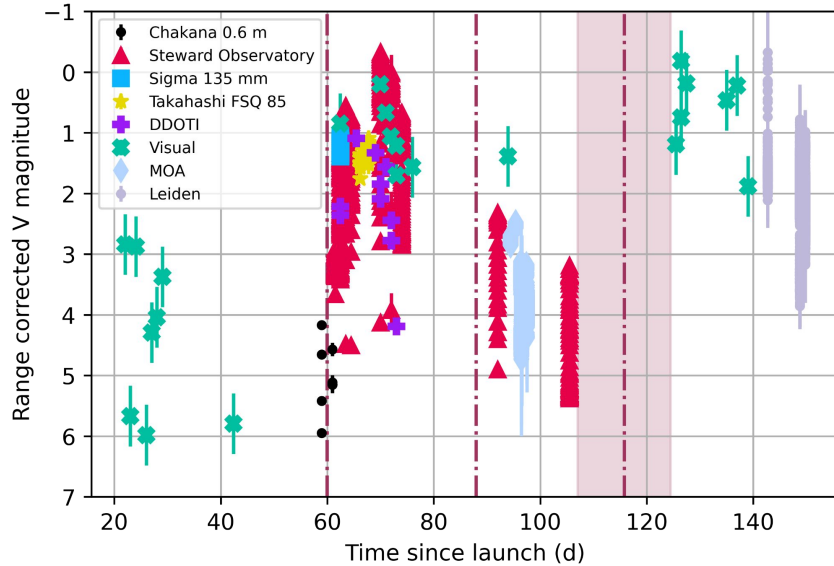
LVM3 Upper stage : 4m diam. x 13.5m long



* observed both in direct sunlight and in Earth's shadow



BlueWalker3: optical bright, maybe also thermally bright?



- 64m^2 phased array, prototype for mobile phone connections using standard phones + satellite
- Optically brighter* than Vega and all except top 10 stars ($\sim 99\%$ of $>\text{mag}6$) (Nandakumar et al., Nature, 2023)
- (+ launch vehicle adapter bright & untracked for first few days, + position predictions degrade over time)
- Planning to launch 5 Bluebirds shortly, followed by even larger arrays ($\sim 250\text{m}^2$) in the future...
- Thermal brightness unknown: have SCUBA2/JCMT time to observe ISS + BW3, observations later this year

(* apparent magnitude)



Thanks for listening!

Questions?

Join CPS!

<https://cps.iau.org>

