

# DARK

# &



Updates on the  
protection of

# QUITE

# SKIES

**Federico Di Vruno**  
Spectrum Manager  
IAU CPS Co-Director

Swiss SKA Days 2023

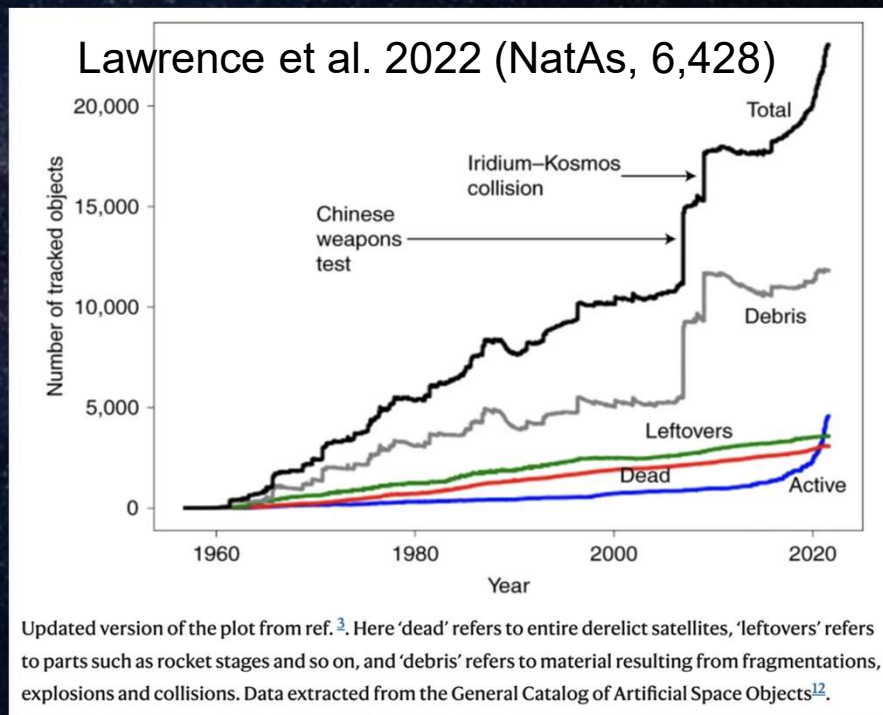


Swiss SKA Days 2023, 08/09/2023



# Activity in Low Earth Orbit

# Number of active satellites (1957-2023)



Active satellites in LEO (200 – 2000 km)

1959 October 1: 1

2019 May 1: ~2,200

2022 Jan 1: ~4,000

2023 Sept 1: >7,700 (Celestrak)

2030+ : >400,000 (based on filings)



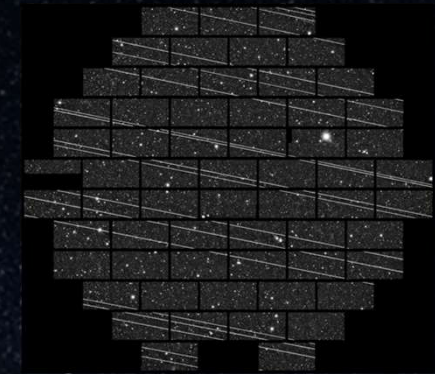
# Satellites can affect astronomy and the night sky

## Sunlight reflection:

- Professional Astronomy
- Amateur Astronomy
- Stargazers
- Cultural heritage
- Nature
- Tourism



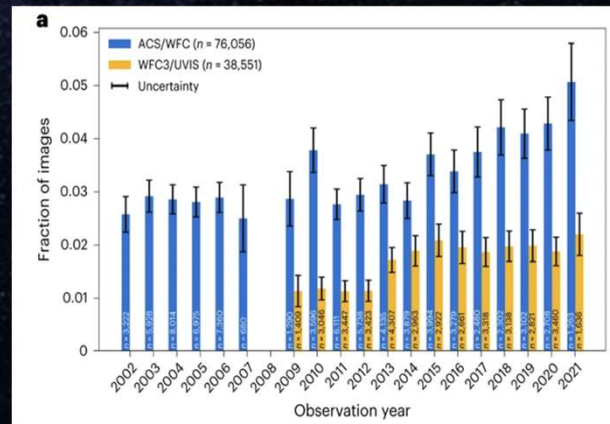
Source: Max Alexander "Our Fragile Space"



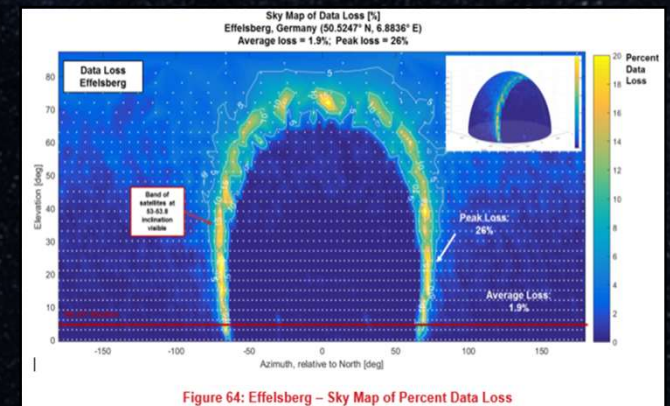
Cerro Tololo InterAmerican Observatory  
Chile

## Radio Emissions:

- Professional Radio  
Astronomy



Fraction of images of the Hubble telescope affected per year (2002 – 2021). Kurk et. Al.



Data loss in 10.6-10.7 GHz band from Starlink #1.  
Source: ECC report 271



# The IAU response



Promoting guidelines  
and regulations at the  
UN COPUOS level



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

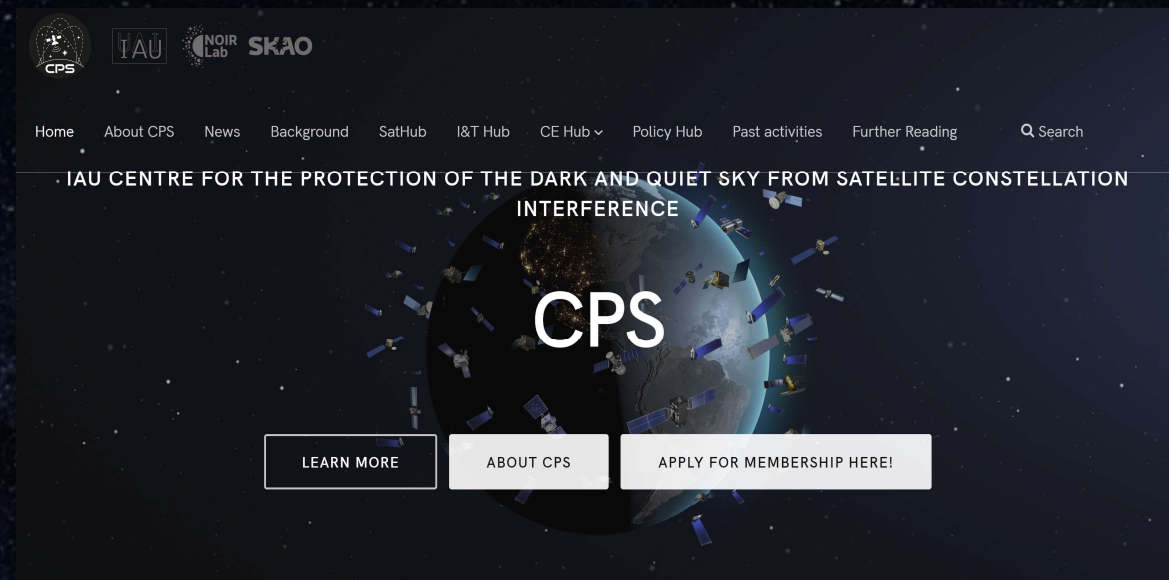


# IAU CPS - a brief summary

<https://cps.iau.org>



- **Coordinate efforts and unify voices**
- **Bringing together different communities**
- **Collect, produce and disseminate information and resources**
- **Open and free products**



- **4 Hubs**
- **> 200 members (astronomers, amateur astro, Astro-photography, communications, policy, etc)**



# IAU CPS Hubs Activities

# Policy Hub

Co-leads: Richard Green and Andy Williams



[policy@cps.iau.org](mailto:policy@cps.iau.org)



- *Raise awareness in policy forums*
- *Study Space policy*
- *Coordinate national societies*
- *COPUOS*
- *ITU*

WP1 Position Document

WP2 Space Law and Policy

WP3 Space Sustainability Rating (Astronomy module)

WP4 COPUOS coordination (IAU, ESO, SKAO, EAS)

- 
- 
- 

WP11 Recommendation compilation and distilling





# Community Engagement Hub

Co-leads: John Barentine and Jessica Heim



[community-engage@cps.iau.org](mailto:community-engage@cps.iau.org)



*CE Hub is CPS' bridge to the community of night sky users beyond professional astronomers. It ensures their voices are part of the broader discussion.*



## Awareness

*Produced set of informative videos  
"SATCONS 101"*

*Providing factual information to inform the  
general public*

## Satellite Basics

### CPS SatCons 101 Training Module 1 The space environment

Collision risks

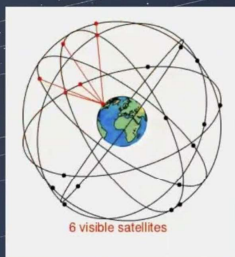


Watch on YouTube [Module 1: Satellite Basics](#)

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## Satellite Constellation Design and Operation

### CPS SatCons 101 Training Module 2 Theory of small constellations



Paul Sava

Small satellite constellations generally consist of < 100 objects.

They can achieve global coverage but have high signal latency.

They can achieve global coverage but have high latency.

Watch on YouTube [Module 2: Constellation Design and Operation](#)

3

## Impacts on Radio Astronomy

### CPS SatCons 101 Training Module 5 How is the radio spectrum shared?

Yellow boxes on this chart are frequencies reserved for radio astronomy.



Watch on YouTube [Module 5: Impacts on Radio Astronomy](#)

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## Awareness

## Impacts to Optical/IR Astronomy

### CPS SatCons 101 Training Module 4 Satellite trails/streaks in images

Satellite trails can compromise astronomical data.



Kees Scherer



CTIO/NOIRLab/NSF/AURA/DECam DELVE Survey

Watch on YouTube [Module 4: Impacts on Optical and Infrared Astronomy](#)

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# Satellites Hub (SatHub)

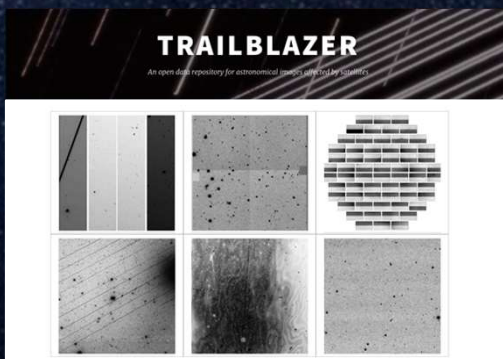
Co-leads: Siegfried Eggl, Mike Peel and Meredith Rawls



sathub@cps.iau.org



- *Observations*
- *Data storage*
- *Orbital predictions*
- *Software*



<http://trailblazer.dirac.dev>

## WP01 Observations & Data Repositories

Coordination of professional and amateur optical & radio observations of satellites (brightness, positions, etc.)  
Data collection and repositories, including TrailBlazer.

## WP02 Orbital solutions

Very accurate satellite positions for astronomical observations; to be used for things like avoidance.

## WP03 Software Tools

Artifact removal, Simulations. Position Prediction, Citizen-science platform

## WP04 Training

Online (or in person) training activities for observing artificial satellites.

# Satellites Hub (SatHub)

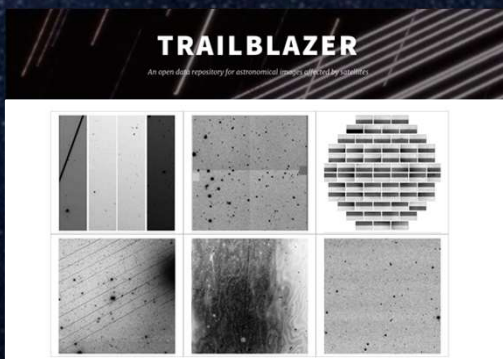
Co-leads: Siegfried Eggl, Mike Peel and Meredith Rawls



sathub@cps.iau.org



- *Observations*
- *Data storage*
- *Orbital predictions*
- *Software*



<http://trailblazer.dirac.dev>

**See Mike's presentation later**



**solutions**

the positions for  
positions; to be  
avoidance.

**aining**

Artifact removal, Simulations. Position  
Prediction, Citizen-science platform

Online (or in person) training activities  
for observing artificial satellites.



# Industry & Technology Hub

Co-leads: Chris Hofer and Tim Stevenson; Advisor: Patricia Cooper



[industry@cps.iau.org](mailto:industry@cps.iau.org)



- *Outreach to industry*
- *Resources to bridge the gap*
- *Promote exchange of information*

## SpaceX, Amazon Kuiper and OneWeb + 4 new members

- Technical Advisory Committee (TAC)
- Astronomy Guides programme
- Resources for Industry

# General status update



# Updates on Dark and Quiet Skies

## Awareness




### IAU CPS Welcomes Support from G7 Science Ministers on Dark and Quiet Skies

18 May 2023

Science and technology ministers of the G7 forum have for the first time stressed the importance of continuing to discuss the impact of large satellite constellations on astronomy

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## Radio noise from satellite constellations could interfere with astronomers

Jeff Foust July 5, 2023









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## Satellite constellations: Astronomers warn of threat to view of Universe

© 27 December 2019



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## Astronomers Worldwide Troubled by New 'Cell Phone Towers in Space'



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[Perspective](#) | [Published: 22 April 2022](#)

## The case for space environmentalism

[Andy Lawrence](#)
[Meredith L. Rawls](#)
[Moriba Jah](#)
[Aaron Boley](#)
[Federico Michael Kramer](#)
[Samantha Lawler](#)
[James Lowenthal](#)
[Jonathan McDowell](#)

Astronomy & Astrophysics manuscript no. output  
July 3, 2023

### Unintended electromagnetic radiation from Starlink satellites detected with LOFAR between 110 and 188 MHz

F. Di Vruno<sup>1,2,\*</sup>, B. Winkel<sup>3,2,\*</sup>, C. G. Bassa<sup>4,\*</sup>, G. I. G. Józsa<sup>3,2,5,\*</sup>, M. A. Brentjens<sup>4</sup>, A. Jessner<sup>3</sup>, and S. Garrington<sup>6,\*</sup>

### THE ASTRONOMICAL JOURNAL

**OPEN ACCESS**

Visibility Predictions for Near-future Satellite Megaconstellations: Latitudes near 50° Will Experience the Worst Light Pollution

Samantha M. Lawler<sup>1</sup>, Aaron C. Boley<sup>2</sup>, and Hanno Rein<sup>3</sup>

Published 2021 December 17 • © 2021. The Author(s). Published by the American Astronomical Society

[The Astronomical Journal, Volume 163, Number 1](#)

Citation Samantha M. Lawler et al 2022 AJ 163 21

DOI 10.3847/1538-3881/ac341b



# Updates on Dark and Quiet Skies *Observations*



***Optical observations of Blue Walker 3  
(submitted to Nature)***

***More observations and modelling  
ongoing:***

***Starlink gen 2  
OneWeb reflectivity models***



***Unintended Electromagnetic Radiation of  
Satellites with LOFAR (published A&A)***



***Ku band downlink measurements with  
Onsala Twin Telescopes and modelling***



# Updates on Dark and Quiet Skies

## International Telecommunication Union

ITU PP-22 – Part II – Resolution 219 405


### RESOLUTION 219 (BUCHAREST, 2022)

#### Sustainability of the radio-frequency spectrum and associated satellite-orbit resources used by space services


*resolves*

- to instruct the Radiocommunication Assembly, as a matter of urgency, to perform the necessary studies through relevant ITU Radiocommunication Sector (ITU-R) study groups on the issue of the increasing use of radio-frequency spectrum and associated orbit resources in non-GSO orbits and the long-term sustainability of these resources, as well as on equitable access to, and rational and compatible use of, the GSO and non-GSO orbit and spectrum resources, consistent with the objectives of Article 44 of the Constitution;
- that the results of the abovementioned studies should be submitted by the Director of BR to the subsequent world radiocommunication conference (WRC) for its consideration and any necessary action, as appropriate,

### ITU Council resolution on Space Sustainability



World Radiocommunication Conference (WRC-23)  
 Dubai, 20 November – 15 December 2023



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PLENARY MEETING
 

Document 50-E  
 10 July 2023  
 Original: English

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Note by the Secretary-General  
  
 REPORT BY THE RADIO REGULATIONS BOARD TO WRC-23 ON  
 RESOLUTION 80 (REV.WRC-07)

#### 4.13 Long-term sustainability and equitable access and rational use of the non-GSO orbit/spectrum resources

WRC-23 is invited to instruct the ITU-R to carry out studies to identify additional information requirements for non-GSO systems and to develop ITU-R recommendations and reports that address the long-term sustainability of the non-GSO and spectrum resources and the equitable access to those orbits and frequencies.

WRC-23 is also invited to urge administrations of Member States of their obligations to continue giving due consideration to the principles of the ITU Constitution, Convention, and Radio Regulations (in particular Article 44 of the Constitution) when developing national policies and regulations to authorize satellite networks or systems.

### Radio Regulations Board on Long Term Sustainability on Non-GSO

*Working on WRC-27 proposals...*

# Updates on Dark and Quiet Skies

## UN COPUOS

*Intense debate at:*  
*the 60<sup>th</sup> STSC 2023*  
*the 66<sup>th</sup> UN COPUOS*  
*2023*



### IAU CPS briefs delegations as United Nations meeting kicks off

🕒 30 May 2023

Ahead of the start of the 66th session of the United Nations' Committee on the Peaceful Uses of Outer Space (UN COPUOS), the IAU Centre for the Protection of the Dark and Quiet Sky from Satellite Con...

[READ MORE](#)



### Dark and Quiet Skies Feature Prominently at UN Meeting

🕒 20 Jun 2023

The issue of the protection of dark and quiet skies from large satellite constellation interference featured prominently at the 66th meeting of the United Nations Committee on the Peaceful Uses of Ou...

[READ MORE](#)

*See Thomas' presentation later!*



# Updates on Dark and Quiet Skies

## *Industry - Constellations*

- *Amazon Kuiper to launch two satellites and discussing coordination of optical observations with SatHub*
- *IRIS<sup>2</sup> (EU constellation) advancing, IAU CPS in contact with the European Commission through the European Astronomical Society*
- *UK “Astra Carta” launched, with the Earth Space Sustainability Initiative. IAU and SKAO signed Memorandum*
- *E-Space filled new filling of 160,000 satellites (France)*

# IAU Symposium 385

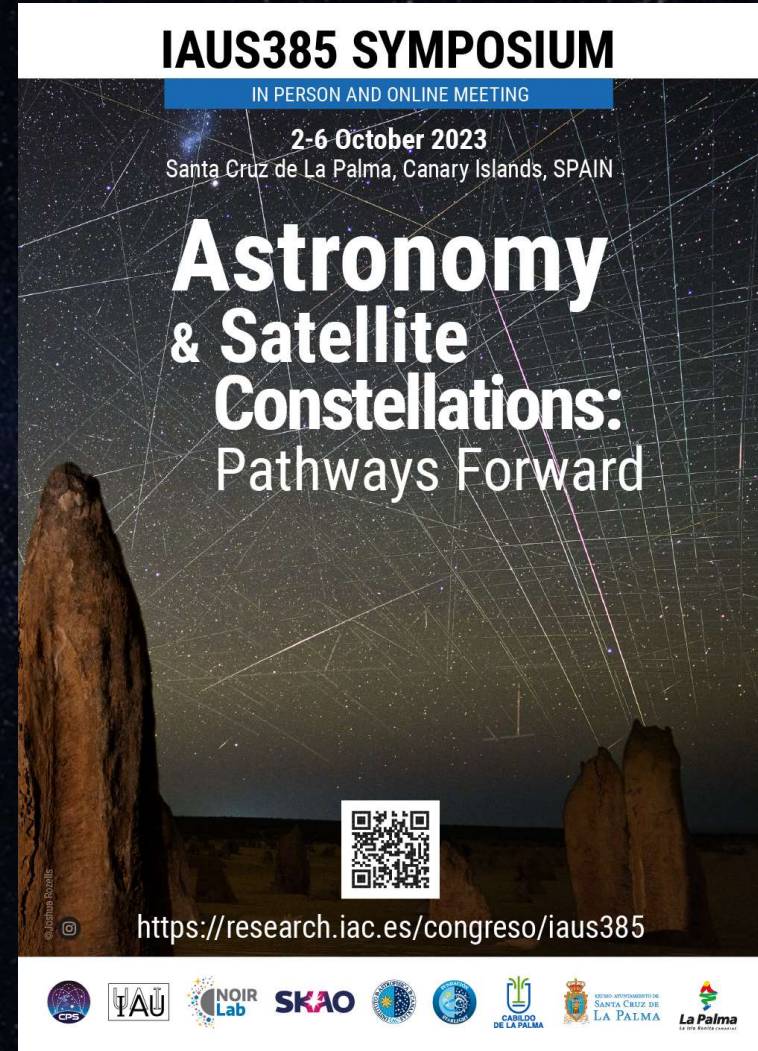


# Updates on Dark and Quiet Skies

## IAU Symposium 385

(2-6 October 2023)

- > 180 registrations so far
- > 80 talks on Policy, Observations, Software, Community Engagement and Industry
- > 40 Posters



**IAUS385 SYMPOSIUM**  
IN PERSON AND ONLINE MEETING  
2-6 October 2023  
Santa Cruz de La Palma, Canary Islands, SPAIN

# Astronomy & Satellite Constellations: Pathways Forward

<https://research.iac.es/congreso/iaus385>

Logos at the bottom: CPS, TAU, NOIR Lab, SKAO, IAC, Observatorio de Santa Cruz de La Palma, La Palma.





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Thank you for your kind attention!

QUESTIONS?

Contact: [federico.divruno@cps.iau.org](mailto:federico.divruno@cps.iau.org)