

Annual Report for 2022

Executive Committee Working Group for Dark & Quiet Sky Protection

Organizing Committee Members: Richard Green (Advisor), José Rodriguez Espinosa, (EC Liaison), Solomon Tessema (EC Liaison), Constance Walker (Chair)

Other Working Group Members

Piero Benvenuti, Lina Canas, Laura Ferrarese, David Galadi-Enriquez, John Hearnshaw, Fatoumata Kebe (Junior Member), Harvey Liszt, Rodriguez Ramotholo Sefako, R. Chris Smith, Diane Turnshek, Yongheng ZHAO

EC WG for D&QS Protection Members have been active in representing the interests of IAU in several major areas:

The IAU Center for the Protection of the Dark & Quiet Sky from Satellite Constellation Interference (IAU CPS)

One year ago (April 2022) the Memorandum of Understanding between the IAU and the Partner Organizations (NSF's NOIRLab and SKAO) was signed and the CPS started its activities. One of the first accomplishments of the IAU CPS was to create a website that provides information on the founding [partners](#) (NSF's NOIRLab and SKAO), the [vision and mission](#), the [governance and staff](#) (which includes the Steering Committee, the Management Team and the Advisory Committee) and the [members](#) (over 250 Affiliated Members and Contributing Members). The heart of the IAU CPS consists of four groups or hubs: [SatHub](#), the [Industry & Technology](#) Hub, the [Policy Hub](#), and the [Community Engagement Hub](#). The [news](#) link on the CPS webpage provides an overview of some of the accomplishments over the year. The IAU CPS has taken a significant role in observations of the brightness (max mag=1) of the BlueWalker 3 satellites; was peripherally involved in the NSF/SpaceX agreement to mitigate impact of Starlink satellites on ground-based astronomy; hosted a town hall meeting of the Industry & Technology Hub; created a "petition" to the UN to address the impact of satellites on dark and quiet skies; supported Max Alexander's "Our Fragile Space" photo exhibit at Lloyd's of London; and is organizing an upcoming IAU Symposium.

Recent accomplishments of IAU CPS SatHub

SatHub Co-Lead Siegfried Eggl formed a network of optical telescopic and visual astronomers to observe BlueWalker 3. Using Slack, they organized an observation campaign, coordinated a research paper, and are about to have it published in *Nature*.

SatHub has started organizing their network of observers to observe Starlink Gen 2 Minis.

SatHub has improved company contacts with Space Situational Awareness data providers (like Privateer, The Exclosure, and Slingshot) and with satellite operators (like AST SpaceMobile, SpaceX, and more) with the assistance of the Industry and Technology Hub.

SatHub has made significant progress with PassPredict (software to predict satellite passes) through a working collaboration agreement with Privateer. Trailblazer, the database for image storage and retrieval, was successfully used for sharing BW3 data.

Recent accomplishments of the IAU CPS Policy Hub

Aaron Boley, co-Director of the Outer Space Institute, is leading the work package of comparative analysis of current national policies. The group is also exploring incorporating mitigation of astronomy impacts into frameworks of international law and long-term sustainability policy. The plan is to have an extensive draft document available for discussion at the IAU Symposium in October, 2023.

Significant progress is being made on adding astronomy protection criteria to the international Space Sustainability Rating, led by the Swiss EPFL. (The EPFL is known as the Swiss Federal Institute of Technology in Lausanne.) The Policy Hub has established an expert panel to advise the EPFL staff. Interns brought on board in early 2023 are developing the criteria further under the guidance of the expert panel.

Andy Williams (CPS Policy Hub Co-Lead) and Piero Benvenuti (CPS Director) and peripherally Federico DiVruno and Connie Walker (CPS Co-Directors) have held discussions with delegations of the UNCOPUOS Science and Technical Subcommittee on the establishment of an Expert Group. The Expert Group would study the problem of mitigating impacts on astronomy to propose a policy framework for STSC and COPUOS approval on a three-year timescale.

Recent accomplishments of the IAU CPS Industry & Technology (I&T) Hub

The I&T Hub identified references to inform and educate stakeholders and the public on topics related to astronomy concerns about satellite constellations and share recommendations for mitigations and best practices. The I&T Hub has developed resources like an Astronomy101 tutorial and a reading list.

The I&T Hub composed a priority operators list and contacted many companies and associations. The Hub held meetings with satellite constellation operators and manufacturers (AST, SpaceX, OneWeb) to participate and collaborate.

The I&T Hub held meetings with Space Situational Awareness data providers like Privateer and Slingshot, so that ephemerides and Two-Line Elements could be obtained for avoidance software.

Recent accomplishments of the IAU CPS Community Engagement (CE) Hub

The Community Engagement Hub pursues two-directional activities. From one direction, it aims to provide the society at large with correct information about the impact of the constellations on the appearance of the night sky, confirming with the other Hubs as to the accuracy of the outgoing information. From another direction, the CE Hub will collect reactions on what that means to people's cultural heritage. In an effort to create a venue in which all stakeholders may be heard and feel safe expressing their opinions and views, the CE Hub established initial contacts with several constituencies.

The CE Hub completed foundational documents, a strategic plan, a couple page "State of the Satcons", and a "SatCons101" curriculum, which includes recently completed scripts and powerpoints that will soon be packaged as videos in English and subtitled in Spanish on:

- Satellite Basics
- Satellite Constellation Design and Operation
- Impacts on the Earth/Space Environment
- Impacts on Optical and Infrared Astronomy
- Impacts on Radio Astronomy
- Impacts on Biology, Culture and Heritage
- Legal and Policy Considerations
- Mitigations

UN COPUOS Meeting and Science and Technology Subcommittee Meeting

From 6 to 17 February 2023, a delegation from the IAU attended the 60th Session of the Scientific and Technical Subcommittee ([STSC](#)) of the UN Committee on the Peaceful Uses of Outer Space ([COPUOS](#)) held in Vienna, Austria. A major topic of discussion during the meeting was the [Conference Room Paper on the Protection of Dark and Quiet Skies for Science and Society](#), which was prepared by the IAU CPS Management Team led by Piero Benvenuti, and presented by the delegations of the IAU, Chile, Spain, Slovakia, Bulgaria, Dominican Republic, Peru, South Africa, ESO and the SKAO. The CRP made two proposals for further action. First, it recommended that dark and quiet sky protection be kept on the agenda of the next three sessions of the

STSC. Secondly, the paper proposed the creation of an Expert Group with the task of promoting awareness of and providing guidance on the impact of satellite constellations on astronomy, as well as enabling communication and cooperation between Member States and stakeholders. Both proposals obtained the support of more than 30 delegations. Several delegations also explicitly praised the work of the CPS and its cooperative approach to the issue.

The creation of an Expert Group is an important step forward in elevating the issue at the STSC meetings. This will give it more of a connection and more visibility. In order to refine the details and gain more support amongst COPUOS members, the team, under the lead of Chile as first co-signatory of the paper, will continue to work towards advocating for the inclusion of the matter under COPUOS at its main session in June 2023.

Focus Meeting #2 at the IAU General Assembly 2022 (IAU GA 2022 FM2)

FM2, "[Toward a World Standard for Dark and Quiet Sky Protection](#)", was a hybrid focus meeting held at the IAU GA on August 4, 2022 and August 9, 2022. Within the two days of FM2, there were ten topical sections that had 45 speakers for 49 oral presentations. After each section there was time for discussion. The SOC Chairperson of FM2 was Connie Walker (IAU C.B7 president; USA). Thanks go to SOC Co-chairs Richard Green (past B7 president; USA) and Narae Hwang (South Korea) and to SOC Members James Lowenthal (next C.B7 president; USA), Sarah Pearce (Australia), Ramotholo Sefako (South Africa) and Diane Turnshek (USA), who along with David Galadi-Enriquez, is the editor for FM2. They also served as topical section chairs and Q&A moderators of FM2, besides presenting.

The first day focused on ground-based light pollution and radio astronomy. Some of the main points that shone through from many talks were:

- Regional and zonal planning to control light pollution is also important. The traditional way of fighting light pollution one streetlight at a time continues to be important, but it's not enough to halt the growth of light pollution. New approaches using limits to allow light pollution in geographic zones—analogueous to air and water quality thresholds used in many countries—may be an essential new tool.
- Astronomers generally recognize that light pollution is a much broader environmental conservation issue than just the visibility of the stars and the Milky Way. Most of us are still in the early stages of building relationships with colleagues in biology, ecology, human health, city planning etc, but those collaborations are likely to be essential in our efforts to bring decision-makers, regulators, and the general public on board to save natural darkness at night.

- It is also important to build mutually respectful partnerships with diverse communities and Indigenous nations—such communities can be highly impacted by these issues, and they need to be consulted and included in decision making processes.

The second day of FM2 focused on the impact of satellite constellations on astronomy as well as related mitigations, both implemented and considered. Highlights included, but were not limited to:

- A new website was launched for the IAU CPS in early 2022 (cps.iau.org).
- By August 2022, over 150 individuals and institutions had signed up to work with the IAU CPS.
- With over 3388 satellites already in the sky (as of August 2022), we are facing potential future numbers of more than 400 000 in orbit, planned by 13 operators so far.
- U. Washington, led by Meredith Rawls, Co-lead of the IAU CPS SatHub, has developed Trailblazer, a data repository for satellite images.
- A network of observers of satellite constellations is amassing images, especially using the eV-scopes.
- The IAU CPS continues to be in active discussion with the major space industries.
- SpaceX removed the reflective visors from their satellites beginning in fall 2021. A new coating is being developed to reduce the amount of light getting directed towards Earth. See <https://api.starlink.com/public-files/BrightnessMitigationBestPracticesSatelliteOperators.pdf>
- The three key results communicated by IAU CPS member, Jeremy Tregloan-Reed, are that the new Starlink's using dielectric mirrors are 27% brighter than the visor design, and the OneWeb satellite's mean brightness while being in the safe zone ($V > 7.9$ for $r = 1200$ km), still has a significant number of satellites being too bright. In addition, like Darksat, they all get brighter toward redder wavelengths, highlighting the need for mitigation designs to work for multiple wavelengths.
- Increasingly sophisticated simulations (involving SKAO) predict what satellite beams will look like passing over a radio observatory.
- NIST in partnership with the IAU CPS and others held a workshop with industry on mitigations strategies for optical astronomy at the end of June.
- The IAU CPS Industry and Technology Hub has drafted a document on best practices.
- The IAU CPS Policy Hub has developed a sophisticated work plan.
- The IAU CPS Policy Hub is involved in work to include the impact on astronomy as one of the modules of the new Space Sustainability Rating.

Other Conferences

In the last year our Organizing Committee members as well as members of B7 gave presentations on light pollution and satellite constellations to many organizations, in many conferences and in front of many government entities too numerous to mention here.

Members involvement in local, regional and national efforts

John Hearnshaw (B7 member and EC WG on D&QS Protection member) submitted a petition to the New Zealand parliament to lobby for national legislation to protect dark skies. The petition is on this website and will be available for signing until April 20, 2023. <https://petitions.parliament.nz/564eab3a-b648-412e-8f3e-2c45b68393d0>

Thereafter it goes to a select committee for consideration and then to the Environment Minister or to the House of Representatives.

A number of B7 members, especially on the organizing committee, have been involved in the International Dark-Sky Association (IDA), soon to be renamed DarkSky International. Connie Walker is on the board of IDA, participating in many of their events on behalf of IDA and IAU. She is on the advisory council of the IAU NA-ROAD, as well as on the SOC for IAUS386. She has been active with the AAS light pollution/satellite constellation group now called COMPASSE, especially in attending governmental meetings with staffers on “the Hill” on satellite constellation issues, which ties in with the IAU CPS Policy efforts. James Lowenthal has also been actively involved in IDA’s awards committee as its chair. Antonia Verala, another B7 organizing committee member, directs the Starlight Foundation. IDA Executive Director has reciprocated with a strong presentation on light pollution at IAU GA2022 FM2. These examples only are the tip of the iceberg.

[Globe at Night](#), the international citizen science campaign on light pollution, got a boost during the IAU International Year of Astronomy and became a legacy project of that as well as a foundational program of NOIRLab. Recently a *Science* journal article was published by [Kyba et al 2023](#) that used Globe at Night data. The paper concluded that the night sky brightness has increased worldwide by 10% a year on average over the last 12 years. Many organizations, social media and news entities have used the results to bring awareness about light pollution issues to the public.

Preparation for IAU Symposium #385 (IAUS385)

The event sites have been reserved. The website for [IAUS385](#) is up and running. The [topics](#) are defined. The [registration](#) form, the [abstract form](#), and a form for the IAU Grant have been created and made available. Important dates have been set and the first announcement has gone out. The entire B7 organizing committee is on the Symposium

Scientific Organizing Committee (SOC). The SOC has met and been asked to help with sending out the announcements and providing topics. Next steps for the SOC will be planning the final program schedule, abstract selection in mid July, and signing up to moderate Q&A discussions or chair sessions.

B7 WG on Site Protection

Chair: Richard Green

The Site Protection WG has been inactive at the collective level over the past year. Participant activity has been either focused at the national level or directed toward satellite constellation efforts. National and local efforts for protection of professional observing sites have been particularly noted in Chile, Spain, South Africa, China, and the U.S. The diversity of activity was showcased at the Responsible Outdoor Lighting at Night (ROLAN) Conference in May 2022 (<https://cibse.force.com/s/lt-event?id=a1E3Y00001nWATPUA4#/Programme>) and Light Pollution: Theory, Modeling and Measurement in June 2022 (<https://martinaube.wixsite.com/lptmm>).

Activities of Richard Green during the last year include:

- Co-Lead, CPS Policy Hub.
- Co-Lead Policy Subcommittee of the American Astronomical Society's COMPASSE group
- Presenter, UN COPUOS STSC Symposium on Dark & Quiet Skies Protection.
- Presenter, ROLAN Conference.
- Presenter of IAU Lighting Activities to CIE Division 4.
- Convener of Arizona Astronomy Consortium (site protection of professional observatories)

Cordially and respectfully submitted on behalf of the Executive Committee Working Group on Dark & Quiet Sky Protection.