Annual Report for 2021

IAU Dark and Quiet Sky Protection Executive Committee WG

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The emphasis of the IAU Executive Committee Working Group on Dark and Quiet Skies and its members in the past year has focused is on the critical issue of the impact of satellite constellations on astronomy and feasible mitigations as well as the creation of the IAU Centre on the Protection of the Dark and Quiet Sky from Satellite Constellation Interference. Complementary effort on the reduction of ground-based sources of artificial light at night is the purview of the IAU Commission C.B7 Working Group on Site Protection. To read the annual report on this latter effort, please refer to the Annual Report of the C.B7 Site Protection's WG or that of the Commission C.B7.

Various members of the IAU Dark and Quiet Sky Protection Executive Committee Working Group (EC WG) have been active in representing the interests of IAU in several major areas:

- The Dark and Quiet Skies (D&QS I) conference was held online from October 5-9, 2020, with more than 970 registered participants. Each daily session was followed by between 250 to 380 online attendees. A draft report, prepared during the preceding months by internationally recognized experts, was made available to the registered participants prior to the event. All participants were then invited to submit written comments within one week of the Workshop's conclusion. Their comments were then used to finalize the Workshop Report. (See https://noirlab.edu/public/products/techdocs/techdoc021/.) The Report represents the most up-to-date and authoritative analysis of the impact on astronomy by three classes of interference: artificial light at night (ALAN), the large number of low-Earth orbit (LEO) satellite trails, and radio-wavelength emission. https://www.iau.org/static/publications/dqskies-book-29-12-20.pdf.
- A special session on the impact of satellite constellations on astronomy was held online at the January 2021 AAS conference and half of an AAS town hall (online) was devoted to the continuation of the same topic at the June 2021 AAS conference. Talks were also given at the European Astronomical Society (EAS), Royal Astronomical Society (RAS), SGAF's Space Generation Fusion Forum and IAU Symposium 367 (on Dark Skies).
- Both a "Conference Room Paper" (CRP) and a Technical Presentation were presented to the online meeting of the UN Committee on the Peaceful Use of Outer Space's (COPUOS) Science and Technology SubCommittee (STSC) on April 21, 2021. Six countries joined the authorship of the CRP before the meeting and delegates from another dozen countries supported the recommendations made within the CRP during the meeting. The outcome of the Dark & Quiet Skies Conference was presented to the

Scientific and Technical subcommittee, notably recommending measures to mitigate the impact of satellite constellations on astronomy, As a result, we were invited to report at the full COPUOS meeting in August. The CRP can be found here: https://noirlab.edu/public/products/techdocs/techdoc022/.

- The primary goal of the online SATCON2 workshop, held July 12-16, 2021, was to develop specific, implementable paths to carrying out the recommendations from SATCON1. (The SATCON1 workshop, held June 29-July 2, 2020, identified the issues and recommended mitigations for the impact of satellite constellations on astronomy. See https://noirlab.edu/public/products/techdocs/techdoc003/.) Over 550 people registered for the SATCON2 workshop. The workshop's two additional goals were to engage a considerably wider group of stakeholders in the conversations than had been presented SATCON1 and to explore existing policy frameworks and present ideas for development of policy capable of addressing an entirely new era in the exploration and use of space. In the couple of months before the workshop, four working groups (WGs) prepared draft reports relevant to the workshop's goals to present their findings at the workshop itself. Two of the working groups, Observations and Algorithms, explored some SATCON1 recommendations directly. The Community Engagement working group brought many new voices and perspectives to the issue, and the Policy working group examined regulatory framework and mitigation approaches from national, international, and industry viewpoints. The final combined report of all the chapters is available as of the last week of October 2021. The Executive Report can be found here: https://noirlab.edu/public/products/techdocs/techdoc031/. The combined report can be found here: https://noirlab.edu/public/products/techdocs/techdoc033/.
- Several briefings were provided over the year to the NSF, the AURA Board, the NOIRLab Management Oversight Committee, the US Office of Science and Technology Policy, the US Board of Physics and Astronomy at the National Academy of Sciences (NAS), the US Committee on Astronomy and Astrophysics at the NAS, the US Space Studies Board at the NAS, the US National Committee for the IAU at the NAS, the US Astronomy and Astrophysics Advisory Committee, the IAU Executive Committee, the Committee on Space Research (COSPAR), the US FCC, the US FAA, the Satellite Industry Association, EAS, RAS, and the Commission Internationale de l´Eclairage (CIE) and many committees and staffers in Washington, DC, USA.
- A presentation was made to the delegates of the hybrid UN COPUOS in August to request a single agenda item dedicated to the topic of satellite constellations' impact on astronomy and society. Consensus was not reached and the request will be revisited at the in-person UN COPUOS Science and Technology Sub-Committee meeting in February 2022. We were also asked to present at the STSC symposium on Dark and Quiet Skies at that time.
- In September 2021, NOIRLab and SKAO in partnership submitted a proposal in response to the IAU call for a Center for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference. The proposal was accepted and the IAU Center (abbreviated to IAU CPS) officially opened on April 1, 2022.
- The Dark and Quiet Skies ll conference from October 3-7, 2021 focused on the

technical and political actions needed to implement the recommendations from D&QS I, in particular identifying which stakeholders and partners would need to collaborate to implement a satisfactory solution for the preservation of dark and quiet skies. Specifically the topics concentrated on satellite constellations' impact on astronomy and society, artificial light at night and radio astronomy. The conference was to be hybrid, but an erupting volcano on the Canary Island of La Palma, caused the conference to be moved entirely online, to not use the resources needed on the island for its inhabitants. The conference program included invited talks as well as contributions selected through a call for abstracts. A total of 724 individuals, 32 percent of whom were women, registered to attend the conference; 77 countries were represented. On average 140 were attending at any one time. Results from the conference will be presented at the UN COPUOS STSC meeting in February 2022.

- From the IAU UNCOPUOS Science and Technology SubCommittee (STSC) report, A/AC.105/C.1/L.394/Add.7: the Subcommittee, at its 955th meeting, on 7 February, agreed to include item 18, entitled "General exchange of views on dark and quiet skies for science and society", as a single issue/item for discussion on the agenda of the fifty-ninth session of the Subcommittee. The representatives of Algeria, Australia, Austria, Chile, Czechia, France, Germany, Indonesia, Italy, the Russian Federation, South Africa, Spain, Turkey, the United Kingdom and the United States made statements under agenda item 18. The observers for IAU and the Square Kilometer Array Observatory also made statements under the item. During the general exchange of views, statements relating to the item were made by representatives of other member States. The Subcommittee had before it the following: (a) Report on the United Nations/Spain/International Astronomical Union Conference on Dark and Quiet Skies for Science and Society (A/AC.105/1255); (b) Note by the Secretariat containing a summary of discussions on dark and quiet skies for science and society (A/AC.105/1257); (c) Working paper entitled "Protection of dark and quiet skies", prepared by Austria, Chile, the Dominican Republic, Slovakia, Spain, IAU, ESO and the Square Kilometer Array Observatory (A/AC.105/C.1/L.396). The Subcommittee noted that, as an ever-increasing number of stakeholders, including private entities, were launching spacecraft into orbit, concerns had been raised about spacecraft that reflected sunlight into astronomical telescopes or crossed their field of view, thereby degrading astronomical observations. Some delegations expressed the view that astronomical observations for both optical and radio astronomy were an essential aspect of space activities and should be protected from interference. Astronomical observations from space and Earth-based installations supported the ability to understand the universe, enabled deep space navigation and exploration and provided early warning detection of near-Earth objects. Some regions had already established practices to preserve the darkness of the sky. The delegations expressing that view encouraged States to follow the examples of those that had implemented regulatory actions to protect astronomy from A/AC.105/C.1/L.394/Add.7 4/5 V.22-00846 artificial light at night in defined areas. Mitigation measures against interference from satellite constellations had been implemented by industry in some cases, especially when it had been possible to engage with astronomers early in the project cycle. In addition, astronomers were devising other ways to reduce the impact of constellations. Some delegations welcomed the initiative taken by IAU in inviting delegations to engage with

its recently opened Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference. The view was expressed that issues identified in relation to artificial light at night would be best discussed at the national level. Some delegations expressed the view that, owing to the rapid evolution in launches of satellite constellations, the ongoing exchange of views on dark and quiet skies should continue to take place in the Subcommittee, with an agenda item on dark and quiet skies for science and society to be included in future sessions of the Subcommittee.

- In addition, several C.B7 members (and D&QS Protection EC WG members and D&QS WG members) presented at the STSC Industry Symposium at the STSC meeting. The two-hour Industry Symposium focuses annually on one theme only and this year it was on satellite constellations' impact on astronomy and the mitigations possible. The symposium was a major opportunity to inform the UN Delegates and to "go on the record". Emphasis was placed on the growing partnership between the astronomy community and industry in achieving feasible solutions.
- Planning by EC WG and C.B7 OC members for the IAU GA2022 Focus Meeting on "Toward a World Standard on Dark & Quiet Sky Protection" is actively taking place.
- Note: future plans in last year's C.B7 triennial report (the D&QS II Conference establishment of the IAU Centre & reporting back to the STSC) were accomplished.