

## **Action Item Paragraphs — OSI Workshop on Orbital Light and Spectrum Pollution (Nov. 16-17, 2023)**

January 30, 2024

### **Introduction**

On November 16 and 17, 2023, the Outer Space Institute (OSI) hosted a transdisciplinary workshop that addressed the proliferating issue of orbital light and spectrum pollution, resulting from the rapid increase in satellites placed in Earth orbits.

The following paragraphs were authored by participants of the workshop. They do not reflect consensus-based or agreed-on recommendations. Rather, they represent a broad collection of rough ideas, suggestions, and potential action items with the aim of advancing the protection of dark and quiet skies from orbital light and spectrum pollution, through education, advocacy, collaboration, and more.

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13. Coordinate letters to policy makers

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27. Refine why we should be with the space sustainability movement
28. Government is a customer, so consider them as a customer (not just regulator)
29. Engage the defence industry think tanks; Engage the aerospace industry; and Engage the Aerospace Corporation
30. Create a public relations (PR) and advocacy toolkit for astronomy groups
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32. Create a forum for easy public advocacy
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38. Engagement with youth organizations
39. Work on including space sustainability in the ITU
40. Engage African astronomical society
41. Definition of the Agenda for the UN Summit of the Future
42. Partnership with the Space Court Foundation
43. IISL Moot Court Competition 2024

44. Further explore a liability claim (“damage”)
45. Bring allies from outside astronomers (not patronizing/ivory tower)
46. An international letter on astronomy as the exploration and use of space OR in support of ASTRO-ICJ (consider which makes most sense)
47. Answer the question what the sky looks like during a total eclipse
48. Time big events and publicity (like an eclipse)
49. Publish a definitive statement on why all telescopes cannot go into space
50. Engage with ground-based telecom industries
51. CPS should create an action and coordination plan (think like a lobbyist)
52. Contact other scientific disciplines
53. Continue to work with astronomy picture of the day
54. Engage the International Astronautical Federation
55. Give Early Career Researchers Equal Opportunities to Participate
56. Get abundance information of space objects from industry
57. Proposed topic for NASA Hackathon (done by Queen’s University)
58. Don’t forget the Historians!
59. Engagement with UNOOSA (Space Law > Capacity Building > Space Law Curriculum)
60. Work better with Indigenous peoples
61. Dark and quiet sky month; Near-space environment day; Coordinate the “days” into a broader, structured event; Use existing days and awareness initiatives
62. Ensure there is a Light pollution panel at PDC 2025
63. Re-engage UNESCO on statement
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65. Outside voices and celebrities
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## **1. Astronomers need to act like we are exploring and using space (because we are)**

Astronomy is “*the scientific study of the universe as a whole and of objects that exist naturally in space, such as the stars*” (Cambridge American Dictionary) and is one of the oldest scientific inquiries. Regardless whether observations are taken from Earth or in outer space, astronomical

observation is unequivocally concerned with the exploration of space. It relies upon detecting electromagnetic, gravitational and/or particle signals from space, and with that, it requires the ability to view the cosmos.

Moreover, a systematic treaty interpretation finds that astronomical observations are an exercise in the exploration and use of outer space, meaning states already have a legal obligation to ensure that other states conducting astronomical observations enjoy the freedoms and protections set out in the Outer Space Treaty.

It is crucial to ingrain in the minds of space policymakers that astronomy warrants the same consideration and importance as other space-related activities and concerns. Getting full recognition of this may take time, and some may argue against this by not conducting a systematic treaty interpretation. Even when faced with resistance, the astronomical community should act like astronomical observations are an exercise in the exploration and use of outer space.

Widespread recognition of astronomical observations as the exploration and use of outer space could prove to be pivotal for establishing appropriate balances between astronomy and other space endeavours.

Examples how to effect action are

1. The IAU making a clear and uncompromising declaration on this topic
2. Ensuring that national societies, observatories and other astronomy communities use this terminology in their public and government engagements, along with issuing official statements.
3. Commissioning a study that collects and then communicates to policy makers and the public the many ways in which astronomy contributes directly to space exploration and key space activities, for example, observations of solar system bodies before visitation by spacecraft, follow-up observation to interpret scientific data, the use of VLBI to enable interplanetary navigation, planetary defence campaigns (e.g., DART), and more.
4. Encouraging astronomers to assert this position in communications with the public and in engagements with policy makers and satellite companies.

## **2. Keep asking “how many satellites do you need?”**

Keep asking satellite companies about the number of satellites they truly need to achieve their goals, how this number is estimated, and whether they can meet their goals by launching a smaller number of satellites. Also question whether satellite companies have estimated the cumulative impacts of radio interference, as well as light and atmospheric pollution from their constellation. The expectation is not for companies to respond right away. Rather, by raising questions about the number of satellites over and over again in various fora, this action could resonate with multiple groups, leading to widespread pressure and compelling companies to eventually answer. Moreover, by consistently posing these questions, the aim is to encourage

satellite companies to evaluate their deployment strategies critically, consider potential environmental impacts, and be prepared to address these concerns as the space industry evolves.

### **3. Increased funding in research on sky and environmental impacts**

In order to better understand the impacts of human space activities (during launch, in orbit, and re-entry phases) on both Earth and space environments, more research is needed. Currently, this is not a well-funded aspect of research, with a relatively small number of academics doing work on this in their spare time. Raising awareness of the importance of these kinds of research and presenting a persuasive case to potential sources of funding is needed. Entities that currently fund science, astronomy and earth science research should be persuaded to allocate more funds to specifically focus on better understanding the impacts of NewSpace activities on the environment. Another possible idea is to approach companies in the space industry to assist with providing funds for such purposes, but with that, comes the risk that researchers funded in such a way may experience pressure to present results in a manner favorable to the space industry - i.e. there may be issues with conflict of interest and insufficient objectivity in the work.

### **4. ‘Stay Focused’**

One option for fostering clarity and focus in our actions is to target distinct fields and issues related to D&QS when producing documents and taking related actions. For example, analyses on regulatory approaches could exclusively be focused on policy and legal texts, along with proposed amendments. Similarly, cultural aspects related to the value of astronomical observation could be addressed in a separate document. By avoiding the integration of various aspects into a single comprehensive document, we may provide clear and concise messages.

Moreover, while short summary documents can encompass various fields and problems, the emphasis could, for example, be on highlighting the imperative need for partnerships between countries and fields. These documents can effectively convey the complexity of D&QS issues, emphasizing the multifaceted nature of the challenges at hand. This approach could ensure that our messaging is impactful and facilitates a strong collaborative response by national and international communities.

(See also discussion below on the sustainability movement for a perspective on broadening the narrative, instead.)

### **5. Get astronomy costed**

Some satellite operators are developing mitigation measures to avoid destroying observations by major facilities. However, many are not. And for the ones that are, effects remain.

Substantial effort may therefore be needed by observatories to minimize the fraction of data affected by satellite constellations, making new development of hardware and software solutions necessary, as well as needing longer observations for the same science.

Solutions will require investment, which may be substantial, not least for the design and implementation of new software approaches to analyze affected data. Sustained funding for these mitigations will be necessary to ensure the future of astronomy, in addition to the increase in time required for fixed mission objectives.

Establishing an estimate for the cost of mitigation is a key piece of information to substantiate the damage to our science and to lobby national governments and other parties for the establishment of compensatory funding.

Moreover, there is an opportunity cost due to data loss from satellite constellations that could potentially have even catastrophic consequences (e.g., reduced ability to predict Near Earth Objects collision events).

The European Astronomical Society is conducting such an exercise for its member states (completion expected in Q1 2024), and that process could be used as a blueprint for a more general evaluation, reasonably doable by the end of 2024.

## **6. Engage Organisation for Economic Co-operation and Development (OECD) concerning costing astronomy**

Acquiring economic data related to the "costs of astronomy" could play a crucial role in advocating for the prioritization of measures to safeguard D&QS and justify the associated economic benefits.

In addition to the other international organizations named during the Vancouver workshop, the Organization for Economic Cooperation and Development (OECD) represents a potential ally for the protection of D&QS and can provide concrete data on the costs of specific actions. Moreover, the OECD is well-recognized and validated at both the international and domestic levels, which could potentially increase the likelihood of support in different countries. Specifically, the OECD has a program within its Science Technology and Innovation Policy (STIP) Division entitled the [OECD Space Forum](#).

The Space Forum has the mission to bring together stakeholders in the global space community to discuss the space economy and its broader impacts. So far, the Space Forum has limited its studies to the economic impact of satellite missions and their positive broader impacts on issues like disaster relief. We understand that an initial contact was made to OECD by CPS last year, which was rebuffed due to a lack of bandwidth. Notwithstanding, we suggest that ongoing communication and dialogue with OECD is in the best interests of IAU and the astronomical community for different reasons.

First, the case can (and should) be made that astronomical exploration of space is an economic activity solidly within the purview of the OECD and is directly connected to the space economy. In fact, the OECD STIP Division already leads the measurements of global research and development activity more broadly. Second, the broader impacts of space exploration in the form of public outreach using astronomical images is something that is explicitly within the remit of the Space Forum.

Should OECD staff still be unwilling to consider this as an issue, IAU should consider engaging countries that have already expressed an interest at COPUOS and ask if they would bring it up through their representatives on STIP. Finally, the OECD is another avenue for creation of soft law regulations, so once light pollution is on the agenda at OECD there is a possibility to use it as an avenue for promulgating helpful regulations.

## **7. Amplify the educational material of the CPS engagement**

The Community Engagement (CE) Hub of CPS has developed a series of SatCon 101 educational videos. These short videos are designed to provide an introduction to the basics of how satellites work, the purpose and functioning of large satellite constellations, as well as an overview of currently known impacts of the constellations on astronomy and the environment. The idea is that once someone has watched this series, they will have a basic understanding of the subject and thus be able to arrive at an informed opinion on the matter and be able to better engage in ongoing dialogue on the topic. CE hub could use assistance with helping to spread awareness of and increase the viewership of this and related educational materials.

## **8. Connecting with those working in the Environmental Studies, Environmental Humanities and Science and Technology Studies (STS)**

While continued scientific research on the impacts of NewSpace activities on the Earth and space environments is essential, it is not the only kind of research that must be pursued in order to better understand and find possible solutions to these issues. The notion of "space sustainability," like Earth-focused sustainability, is inherently multi-disciplinary in nature. Engineering and scientific knowledge alone will not solve the concerning issues brought about by SatCons and related space activities, as these activities exist within the context of human systems. Thus, in addition to looking at technical, policy, and legal solutions to these issues, it is also imperative to engage with scholars who have a long history of studying complex sustainability issues from the lenses of the humanities and social sciences as well. Additional opportunities for researchers from these fields to work collaboratively with those studying scientific and policy/legal aspects of use of the space environment should be found in order to better understand these issues and to have the best hope at finding solutions that may actually work in the real world.

Perhaps an "Environmental Issues in Space" sort of conference could be planned and designed so that scholars from these diverse fields can present their research, learn from one another, and find ways to work together to pursue more effective ways forward in this area.

## **9. Understand the benefits of astronomy**

The wider impact of astronomy is well documented, and primarily consists of the direct economic benefits, such knowledge transfer, spin-out companies, contracts for companies from major projects, and training of highly skilled individuals. Astronomy is also seen as a ‘STEM attractor’ in persuading young people to pursue study and careers in science.

Organisations including the European Southern Observatory, the International Astronomical Union, the Office of Astronomy for Development, and the Royal Astronomical Society have pre-existing materials setting out these benefits, and further case studies are in sources like the 2021 UK Research Excellence Framework.

We suggest a desk exercise is carried out to collate these findings across different countries, alongside those created by multinational facilities. The objective would be to create a single document appropriate for policymakers.

A realistic timescale for completion would be the summer of 2024.

## **10. Build on Astrotourism**

In order to raise awareness of and increase the number of parties interested in the issue of the impacts of large satellite constellations on astronomy and the environment, it is essential to reach out to individuals and groups beyond those focused on professional astronomy. All those who view and engage with the night sky for various reasons should be considered stakeholders potentially impacted by changes in the night sky. Such possible additional stakeholders include those engaged with astrotourism, astrophotography, and/or amateur astronomy. Efforts should be made to reach out to such groups and organizations in order to engage with them on the topic.

## **11. Make allies**

To date, the narrative around satellite constellations is that they bring the benefits of connectivity to many people, with negative impacts primarily affecting professional astronomy. As we learn more about the field, it is clear the impacts extend beyond optical and radio astronomy. The environmental impacts were outlined in a [2023 paper by Gaston et al](#), and the cultural impacts were covered in the SatCon workshops. Broadening the community concerned over the impact of unfettered industrialization of low earth orbit is essential to addressing the problem. Becoming effective allies will require the astronomy community to determine if it is willing and able to join with other communities concerned about, for example, climate change, ozone depletion, and wildlife loss, as well as those local communities impacted by launch infrastructure.



## **12. International Union for the Conservation of Nature (IUCN) (access United National Environment Programme (UNEP))**

Several United Nations agencies have missions that will be affected by the rapid industrialization of low earth orbit. In addition to educating UN COPUOS, we could engage with other agencies that work in allied areas. There are several possible avenues to explore. In 2020, the United Nations Environment Program (UNEP), Convention on Migratory Species [adopted](#) “Light pollution guidelines for wildlife including marine turtles and migratory shorebirds”. The UNESCO World Heritage Convention has an [Astronomy and World Heritage Initiative](#) that seeks to conserve the sky as our “common and universal heritage.” The International Union for the Conservation of Nature (IUCN) is a UN body that acts as a policy and scientific advisor in support of the 2030 Agenda for Sustainable Development and several other biodiversity-related conventions. They rely on Earth-observation satellites to conduct their assessments – which are put at risk from the crowding of low Earth orbit. Their work to conserve biodiversity is also at risk from the impacts of satellite constellations.

## **13. Coordinate letters to policy makers**

Most launch activities in the United States and Europe have some form of regulatory oversight, including public review and comment periods. Consistently raising concerns during this period to policy makers will elevate the profile of the issue and open the door to groups pursuing legal challenges to resolving unclear or unanswered questions. Further, in the policy arena, law makers are hearing extensively from the well-financed satellite industry. A coordinated campaign would ensure that law makers are hearing consistently from other interested parties as well. Ideally, this works alongside the allyship strategy to ensure law makers are hearing from groups other than astronomers.

## **14. Get behind ASTRO-ICJ**

In supporting the ASTRO-ICJ initiative, get involved, and spread the word. Incorporate this into many of the other actions discussed in this document.

## **15. Engage private investors into astronomy**

Private philanthropy has played an important role in funding astronomy from its inception to the present day. Many major observatories have relied on private investors to fund some or all of their facilities, and those investments are now being put at risk by outside forces on the ground and in space. As business-people, private philanthropists understand risk, but they also can be incentivised to counteract those risks. The International Astronomical Union (IAU) could convene a small task force supported by the Centre for Protection of the Dark and Quiet Sky (CPS) and the directors of a just a few key privately supported facilities (e.g. the Simons Observatory, Giant Magellan Telescope (GMT), Thirty Metre Telescope (TMT), as a start) to ascertain private philanthropists' interest in protecting their investments. Some examples of

actions the philanthropists and their foundations could take include financial support for the activities of CPS, communications campaigns to educate local communities, governments, and the general public about the issue, or even direct conversations with investors of large constellation companies. This group might also be leveraged to engage with the investors in the large constellation companies themselves.

## **16. Engage investors in megaconstellations**

Companies developing, fielding, and operating large satellite constellations, in particular those domiciled in Western countries, have investors. These investors can influence company behaviour and outcomes. Research could be initiated to identify the private investors in large constellation companies, and in particular those investors that might be partially motivated by sustainability, ethical, and/or impact investing motivations. Efforts could also be made to identify particular investors where contact might be easier (for example the Ontario Teachers' Pension Plan has in the past made significant investment in SpaceX). In identifying investors, those who invest in venture funds, which in turn invest in companies, might also be considered (i.e., venture firm's limited partners). A campaign might then be initiated to engage these investors in supporting efforts to mitigate the impact of large constellations on astronomical observations. In this campaign it is unlikely that investors will be influenced to stop large constellation deployment or operations (after all, the investors are seeking financial return from those investments), however investors may be able to influence company behaviour both in following through on voluntary mitigation commitments, and in minimizing the size of deployed constellations. In addition, some large constellation operators might be publicly traded companies - or have long term objectives of becoming publicly traded - activist shareholders can also be successful in influencing company behaviour.

## **17. Keep working on studies of THE number of satellites**

What constitutes too many satellites is not an easy question to address, as the impacts have many considerations. For example, naked eye visibility, variability, infrared brightness, and radio emissions all contribute damaging dark and quiet skies, but in different ways. Ongoing studies of the current and forecasted situations remain necessary for putting satellite impacts into perspective, as well as to understand how observatories (large and small) around the world will be affected. Moreover, satellite designs are constantly evolving. Thus, ongoing study is necessary to keep an up-to-date assessment of the situation. When considering broader impacts, a positive change for one type of impact could be a negative change for a different impact. Overall, an Earth-Space system approach is necessary and must continuously be addressed.

## **18. Plan international conference on Earth-Space environment**

Contacting other scientific disciplines and “joining forces” could be fruitful. One possibility is to organize a joint conference on the “Earth-Space environment”. This type of conference could

have two goals and, depending on which is being targeted, the format of the conference would differ:

- **Connecting communities and sharing perspectives:** This can be a relatively small workshop of the leading voices in each community (non-exhaustive list: atmospheric science, astronomy, space debris, light pollution, effects of light on animals, etc). This workshop can last for 3-4 days with about 50-70 attendees, having some plenary talks and with emphasis on interdisciplinary discussions. This workshop can refine the idea and the SOC for the following conference.
- **Showing a coordinated approach to Earth-Space Environment:** large conference (several hundreds of attendees) inviting researchers of all the areas to present their work.

## **19. Include citizen scientists**

Astronomy projects were among the first to feature citizen science programmes, arguably historically (few professional scientists existed before the nineteenth century) and in recent times, where web portals such as Zooniverse have more than a million registered users.

There is an opportunity to engage citizen scientists in analysing data on the impact of satellite constellations, such as in identifying trails in images, and characteristic signals in radio data. This work could simultaneously help us to build the dataset on the detrimental effects and to create a new set of deeply engaged volunteers. This cohort should be our natural allies in making the case for protecting dark and quiet skies in wider society.

We could make contact with citizen science specialists in astronomy, bringing them clearly identified projects that will create data appropriate for volunteer analysis. In collaboration with the CPS Sathub team we could expect an online gateway for this project to be developed by the end of 2024.

## **20. Show people how the sky is changing**

Many are now disconnected from naked-eye observation of the night sky due to urban light pollution, so most urban dwellers will only notice satellites in the dark sky if/when they go camping or go to a cabin. How do we get people to mourn the loss of darkness when many don't have any direct experience viewing the unpolluted night sky? One possible strategy is to help people connect with our history of night sky observing and stories – every culture in the world has stories and traditional knowledge associated with patterns in the sky, and everyone should feel some loss for not having access to this. A direct action is to encourage public observing nights, which many astronomy departments and amateur astronomy clubs already host, and in these include dark and quiet sky educational programming. The more people who connect with the beauty of the night sky, the better!

## **21. Op-eds and letters to editors in newspapers**

Opinion articles are opportunities for experts to write informative pieces that reach audiences beyond academia. They are educational devices that cast wide nets of exposure, attracting readership from the general public and empowered policymakers alike. Appealing to the reader's concern for environmental activism and intergenerational equity will generate a sense of urgency. A new article could centre around the Dark & Quiet Skies initiative, including:

- The definition of Astronomical Observations
- The lack of a globalized regulatory body for LEO satellites
- The increase of Starlink satellite streaks
- Impacts on the environment and people's right to the night sky

Publishing in a journal that is not space-related could spread awareness and spark a genuine curiosity about science in non-experts. These journals include but are not limited to: The Globe & Mail, The Washington Post, The New Yorker, The Economist, The Atlantic, LA Times, Scientific American, Popular Mechanics, etc.

## **22. Request 1-on-1 meetings and briefings with regulators (especially with comment periods)**

Numerous countries are presently revising or establishing fresh space policies and regulations, some of which involve public consultations to gather input from space stakeholders. Notably in 2023, countries like Canada, the UK, the European Union, and Chile have initiated such consultations. These forums offer an opportunity for potential policy changes and encourage government bodies to be open to new perspectives. Apart from the formal submissions made, the astronomy community, through national societies or observatories, can seek meetings with space regulators to address pertinent issues and raise awareness of the dark and quiet skies topic. Typically, corporate lobbyists attempt to engage in similar meetings but are redirected towards public consultations. In the case of astronomy, where there are no direct commercial conflicts, leveraging these avenues might yield more favourable outcomes.

## **23. Identify first-mover states for norms**

An important step towards building new international norms and changing the behaviour of states is identifying and unifying states that would be "first movers" or champions of an issue. "First movers" are important for generating initial momentum on an issue by bringing this issue to international bodies, building alliances with other likeminded states, and advocating for coordinated action. These are states that might be supportive of and willing to submit a request for an ICJ advisory opinion on dark and quiet skies.

Moreover, groupings of likeminded smaller states also help to unify less materially or hegemonically powerful states under an umbrella to better leverage their interests in the face of potentially oppositional powers such as the US, China, etc. Civil society and dark and quiet sky campaigns can also point to these states and praise their leadership on this issue as an example for others to follow.

This approach has been integral to international norm and treaty campaigns such as the development of the 1968 Nuclear Non-Proliferation Treaty, the 1997 Land Mine Ban Treaty, and the 2008 Convention on Cluster Munitions.

#### **24. Talk to PR strategists for messaging**

Raising awareness and concern about dark and quiet skies amongst the public is important for generating pressure and policy change. To do so, the CPS might consider launching a public relations campaign. This might include a series of public-facing op-eds, video series of short and accessible explainers, and/or a social media campaign on viral platforms such as TikTok and Instagram. Such a campaign would help capture and re-frame the public narrative on satellite constellations.

#### **25. Conduct a full lifecycle analysis**

A life cycle assessment (LCA) is the process of assessing the environmental impact of a process from raw material extraction and processing (cradle) to final disposal (grave). The [European Commission](#) has developed a platform to support assessment and it is becoming integrated into EU policy initiatives like the Green Deal. Advocating that a complete LCA be conducted on satellite constellations, that require the production, launch, maintenance, and disposal of thousands of satellites per year for a single constellation would highlight the considerable cumulative environmental cost of this novel infrastructure.

#### **26. Get astronomers to make this an issue (start with land acknowledgement, end with sky recognition)**

A major issue for light and spectrum pollution is the fact that most astronomers are only cursorily on board with the effort. It is a rare occasion when an astronomer discusses the problem of spectrum pollution in their scientific talk to their peers, even though other issues in their research are often discussed. For example, everyone knows that stellar flares and variability are a problem for people who study exoplanets; the Milky Way foreground is a nuisance for cosmologists; and glitches ruin LIGO data. Why do so few astronomers talk about how bad the situation is becoming with particularly spectrum pollution?

Advocating for astronomers to insert a slide at the end of their talk to highlight what spectrum and light pollution from satellites will do to their data and how it can impact the science is an excellent and low-cost way to encourage more astronomers to be involved.

Possible action items:

- Start by ending your talks with a slide on spectrum pollution
- In that slide encourage others to do the same

## **27. Refine why we should be with the space sustainability movement**

Light and spectrum pollution is just one consequence of industrializing outer space. But this issue alone is difficult to communicate with people, especially because so many have already lost a connection with the sky. With this in mind, the industrialization of outer space comes with a suite of interconnected challenges, such as orbital debris, casualty risks, risks to space-based services, and pollution of the atmosphere – some of which could be more easily understood by people (and governments). There needs to be further developments showing how preserving astronomical observations from Earth fits into the growing space sustainability movement. This could be particularly useful when exploring the broader context of environmental damage or how rules to take care of one problem could actually make other problems better or even worse.

(See also ‘Keep Focused’ for arguments on keeping communications narrow for sake of clarity)

## **28. Government is a customer, so consider them as a customer (not just regulator)**

Beyond their roles as regulators, governments could also be approached on D&QS issues as customers of satellites and satellite services. As customers, they can give additional priority to satellite operators and manufacturers that employ light and spectrum pollution mitigation measures. For example, in the US, the Department of Defense procurement and bidding process could include a bump given to companies that have demonstrated compliance with best practices for D&QS. In order to bring about this change, it will be necessary to convince governments that D&QS preservation is to their benefit as customers. One way to do so could be to highlight the national security interests inherent in preserving D&QS, through reliable spectrum access for interference-free communications, as well as the ability to carry out cislunar space situational awareness with ground-based optical sensors.

Possible action items:

- Initiate conversations with the relevant agencies and departments carrying out commercial satellite contracts within a country (e.g., in the US this would be the Space Development Agency and the US Space Force Commercial Space Office) to better understand the bidding process, and highlight the connections between D&QS and national security interests.
- Make the case for this change to the procurement process to governmental advisory groups, e.g., in the US, approach the Users’ Committee of the National Space Council.

## **29. Engage the defence industry think tanks; Engage the aerospace industry; and Engage the Aerospace Corporation**

Additional allies in D&QS advocacy efforts could be think tanks and foundations including:

- Secure World Foundation
- Union of Concerned Scientists
- Federation of American Scientists
- Aerospace Center for Space Policy and Strategy
- Center for Strategic and International Studies

- Stimson Center
- And many others

These organizations can both contribute to research on policy and legal pathways for the preservation of D&QS, while also assisting in advocacy efforts, through their media centers and lobbying arms. The goals of D&QS align well with the goals of these organizations, from promoting safe and sustainable space environments to putting rigorous science into action to enable a safe and just future, as well as promoting international security and shared prosperity.

In addition to think tanks like the ones above, it could also be important for D&QS advocates to engage with potential allies within the aerospace industry. Beyond working with satellite operators and manufacturers on mitigation measures, we should also be in conversation with companies focused on space sustainability, including Slingshot Aerospace (which carries out optical brightness measurements through its Slingshot Vantage service), and Astroscale (which focuses on on-orbit servicing, but has space sustainability as its core mission). Engaging with these and other companies could allow us to communicate D&QS concerns, and explore options for data sharing and joint advocacy on this aspect of space sustainability.

### **30. Create a public relations (PR) and advocacy toolkit for astronomy groups**

The creation of a PR and advocacy toolkit for astronomy groups represents a significant opportunity to allow, on the one hand, astronomy groups in different countries to have a common discourse regarding the protection of D&QS and, on the other hand, to allow these groups to communicate in different decision-making spaces at national levels.

This could be significant for the development of national legislation, which is still a task in progress for most if not all countries, and for how those nations discuss the issue of satellite constellations in international forums.

We could draw on the expertise of the public policy professionals and communications specialists, based at astronomical facilities, in national societies and in research organisations, to create a generic toolkit. This will set out a series of steps for raising the profile of the issue of satellite constellations, including recommendations on audience analysis (e.g., public servants, elected lawmakers, media and the wider public), core messages and hard data on the impact of satellite constellations on astronomy, model letters and press releases, and multimedia resources.

The completed toolkit could then be disseminated to national representatives via the International Astronomical Union, and regional organisations such as the European Astronomical Society and the African Astronomical Society.

A reasonable timescale for assembling this toolkit is the summer of 2024.

### **31. Run social media campaigns**

Promoting global sustainability issues via social media platforms can be an effective way to reach a large and diverse audience. This includes (but is not limited to) podcasts, educational videos, posting on LinkedIn, Facebook, Twitter, etc. However, resorting to more rapid information apps like TikTok and Instagram could be best considering the lack of attention the issue has now.

A campaign on satellite mega-constellations and the resulting sustainability concerns (or just light pollution) could be done in coordination, whereby multiple organizations (e.g., OSI, IAU CPS, observatories, astronomical associations and organizations, academics) produce a wide range of content, for instance YouTube videos, IG and TikTok reels, and so forth, and release them simultaneously and for a sustained period — attempting to make the issue go viral for a short period.

Such an effort might have to resort to a more sensationalized presentation of the issue, wherein striking visuals and catchy—almost click-bait-like—facts are delivered to audiences through short videos, i.e., reels, or even in meme format.

### **32. Create a forum for easy public advocacy**

Sending a letter to your member of Parliament/Congress (MoP/C) can be an effective way to participate in political advocacy. Online forms make it easy for people who care about a cause to make an impact without having to dedicate more than a minute of their time. This could be a great thing to point people to when giving a talk (either to astronomers or a broader outreach talk) and could be linked to other initiatives, such as astronomers including slides regarding spectrum pollution. It could also be used in email campaigns to catalyze advocacy. A good example of this can be found on the American Physical Society website: <https://p2a.co/AlcbGGS>.

Possible action items:

- Write a short blurb outlining key points in the Dark and Quiet Skies initiative to contextualize the online form.
- Compose a template email that will be sent to MoP/Cs containing a call-to-action.
- Consider using different template emails depending on whether the sender is an astronomer or a member of the public.
- Create an online form where participants can input their postal/zip code and relevant personal information. Once submitted, the form will automatically send the template email to the participant's corresponding MoP/C. The American Astronomical Society has purchased the software to enable this capability, but has not yet set it up, so perhaps we could work with them to do so?
- Modify the template as needed to include relevant asks when new draft legislation arises.



### **33. Continue research to strengthen legal arguments across all issues (attention to Astro-ICJ)**

The early thoughts on approaching the International Court of Justice (ICJ) now dubbed '[Astro-ICJ](#)' were discussed at length. Workshop attendees recognised that this would be a critical step in establishing solid legal foundation for the protection of dark and quiet skies. There was consensus in the group that, an Advisory Opinion by the ICJ pronouncing that states have a responsibility under international law to protect dark and quiet skies, would be significant in achieving the aim of promoting astronomical activities.

Conveners of the workshop shared early thoughts with the group, in the form of a memoranda to propose legal arguments to the ICJ and ways to make a case for the matter to be heard at the ICJ. It was noted that the work done to date on the memoranda set the stage for a focused discussion. However, participants also noted that the legal arguments need expansion, strengthening and better formulation.

The starting point for this was that more and careful attention should be given to the questions that would be presented to the ICJ. The framing of the questions must be done consistent with the procedures in which the ICJ operates to increase chances of success. It was agreed that engaging experts in ICJ matters to frame the questions would significantly increase the chances of getting it right from the onset. On the question of ensuring that the legal argument is precisely elaborated and strengthened, it was proposed that consideration is given to widening the scope of the potential Advisory Opinion to expand aspects of the dark and quiet skies wider than astronomical activities. This would include areas such as space sustainability, space debris and concerns around light pollution associated with operation of Low Earth Orbit Satellites.

It was noted that other areas of international law that have developed over years, such as law of the sea, have developed legal principles that the Astro-ICJ might lean into. The principles that have evolved and tested over time, to protect other areas of the global commons will help strengthen the case for the ICJ to pronounce itself on the question of state responsibility in protection of dark and quiet skies.

### **34. Explain the legal issues in ways that non-lawyers understand**

One of the reoccurring issues for discussion at the workshop was the need for communicating the problem in ways that get more people globally concerned about the protection of dark and quiet skies. One of the ways in which this could be done is ensuring that the language used to explain the legal issues is accessible and understandable to people with non-legal backgrounds.

It is a known fact that specialists in their areas often write in language only accessible to those with technical understanding of the respective subjects. The problem with this approach is that it isolates large numbers of people who would otherwise have engaged with the subject if the language had been more accessible and understandable. Therefore, if this group wishes to increase the number of people concerning themselves with these questions, we must build interest and support across jurisdictions and communicate the reasons why societies in the global

north and the large majority in the global south, then the language used must be such that is understood across multiple disciplines.

### **35. Explore regional options along with international and national ones**

As discussed at the Vancouver workshop, there is a need to explore partnership opportunities at both international and national levels to enhance awareness on the protection of D&QS. The current lack of awareness regarding D&QS issues necessitates our engagement with various formal and informal entities. In this respect, IAU CPS has to continue an in-depth analysis of the national regulatory approaches to the protection of D&QS. Following this, countries with the greatest potential for addressing D&QS issues at the national, regional, and local levels need to be identified.

Subsequently, we could reach out to noteworthy national D&QS initiatives and other relevant entities, such as environmental organizations, scientific groups, national and regional space agencies, and governmental commissions, among others. The aim would be to raise awareness about D&QS concerns and contribute to altering the perception of dark skies and astronomy. Additionally, we suggest contacting influential knowledge disseminators and think tanks to raise awareness on the protection of D&QS among the general public in specific countries. This outreach will also support potential changes in national policies regarding D&QS protection.

### **36. Articulate clear thresholds for harm**

For regulatory agencies to be able to take DQS issues into account during the licensing process, D&QS advocates need to articulate clear thresholds for harm, i.e., how many satellites, with what brightness levels, would be too many. Based on the requirements of the Vera C. Rubin Observatory detectors, satellite brightness should be no greater than 7 mag. to minimize uncorrectable cross-talk in Rubin images. Additional investigation is needed to understand potential harm to other observatories in addition to amateur astronomy and other communities, as well as the corresponding potential mitigation measures. Beyond a limit on mean satellite brightness, we also need to articulate a limit on flares, particularly how many flares per orbital pass damages too much data. Similar thresholds are needed for spectrum pollution. Although radio astronomers do not have passive rights to most frequencies, we should prevent these frequencies from being made inaccessible as a result of steady noise build-up. It is therefore essential to answer how much bandwidth in various frequencies can be dominated by noise before radio astronomy interests are severely compromised. Articulating clear thresholds might help enable regulatory agencies to consider aggregate effects in their licensing procedures, as they can determine how much a single filing should be able to contribute to reaching that threshold.

Possible action items:

- Encourage national agencies to provide financial support for studies to determine these thresholds via simulations.

- Begin studies to estimate rough numbers now, and make it clear that these are subject to change as we gain a more sophisticated understanding.

### **37. Coordinated astronomy on tap**

Astronomy on Tap (<https://astronomyontap.org/contact/>, AoT) is an event where astronomers, educators, writers and artists give accessible presentations about their work on space science at local bars. These events are held regularly all over the world, with 59 active locations listed on their website. AoT is a popular and widespread outreach initiative that could be leveraged to spread awareness and catalyze public advocacy on Dark and Quiet Skies issues.

A particularly impactful event could be to have a coordinated AoT month focused on dark and quiet skies and space environmentalism issues. This would involve having each AoT chapter organize talks that month related to these topics, and encouraging attendees to advocate for mitigations. The action items needed to make this happen include:

- Reaching out to each AoT chapter to see if they would be willing to set aside a month.
- Assisting local AoT organizers with finding local speakers on these issues and providing materials as needed to the speakers to ensure consistent messaging.
- If local speakers can't be found, perhaps recording some talks that could be shown, or organizing an online webinar that local AoT chapters could direct their audiences to.
- Including clear asks for public advocacy at the end of the talks/events (e.g. a link to contact the relevant government representatives, or even a template of an email that could be sent).

### **38. Engagement with youth organizations**

Engaging youth organizations in the space sector is crucial for advancing the protection of dark and quiet skies and fostering research on this topic. These organizations, such as Space Generation Advisory Council (SGAC), Students for the Exploration and Development of Space (SEDS), and the Space Court Foundation, play a pivotal role in harnessing the enthusiasm, innovation, and global perspectives of young minds to address challenges related to the preservation of the outer space environment.

- Space Generation Advisory Council, with its extensive global reach, organizes numerous national, regional, and international events, providing a platform for young professionals and students to collaborate, share ideas, and contribute to the discourse on dark and quiet skies. With observer status at the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) and the Economic and Social Council (ECOSOC), SGAC enables young voices to be heard on the international stage, influencing policy discussions and decisions that shape the future of space activities.
- SEDS, with its widespread network of groups in universities worldwide, by involving students in hands-on projects and research related to dark and quiet skies, could contribute to the development of practical solutions and foster a sense of responsibility

among young space enthusiasts to protect the outer space environment for future generations.

- The Space Court Foundation's significant work in space law and policy developments is essential for establishing legal frameworks that govern activities in space. Engaging with this organization allows young professionals to contribute to the formulation of regulations that address the challenges of maintaining dark and quiet skies, considering the potential impact of space activities on astronomical observations.

Possible action items:

#### 1. Collaboration Initiatives

- ⊘ Establish Partnerships: Initiate formal partnerships and collaboration agreements between the IAU and youth organizations such as SGAC, SEDS, and the Space Court Foundation to leverage their networks and expertise.
- ⊘ Joint Events and Workshops: Organize joint events, workshops, and seminars with SGAC, SEDS, and the Space Court Foundation to facilitate knowledge exchange, dialogue, and collaboration on the protection of dark and quiet skies.

#### 2. Educational Outreach:

- Support Educational Initiatives: Provide support and resources for educational initiatives led by SGAC/SEDS, such as projects or campaigns aimed at raising awareness about dark and quiet skies among students.
- Guest Lectures and Webinars: Offer IAU experts as guest lecturers or webinar speakers for SEDS chapters, SGAC events, and Space Court Foundation projects to share insights on astronomical observations, the importance of dark skies, and related topics.

#### 3. Research and Policy Collaboration:

- Contribute to Research Projects: Collaborate on research projects exploring legal and policy aspects of protecting dark and quiet skies, bringing the IAU's astronomical expertise to the forefront.
- Technical Guidance: Provide technical guidance and expertise to youth-led initiatives focused on developing practical solutions for minimizing the impact of space activities on astronomical observations.

#### 4. Advocacy and Communication:

- Joint Advocacy Campaigns: Launch joint advocacy campaigns with SGAC, SEDS, and the Space Court Foundation to promote policies and practices that prioritize the preservation of dark and quiet skies.
- Communication Channels: Establish regular communication channels between the IAU and these youth organizations, fostering ongoing dialogue, and ensuring the integration of young voices in discussions related to dark and quiet skies.

#### 5. Mentorship and Leadership Development:

- Mentorship Programs: Institute mentorship programs that connect young professionals from SGAC and SEDS with IAU members, fostering knowledge transfer and nurturing leadership in the field of astronomy and space policy.

- Youth Representation: Encourage youth representation in IAU committees and working groups, ensuring diverse perspectives and ideas are considered in decision-making processes.

### **39. Work on including space sustainability in the ITU**

Using the recently approved resolution on sustainable use of the radio spectrum and the space orbits, interested parties are encouraged to collaborate with ITU members (Sector members or States) to submit a proposal for a recommendation on space sustainability to a working party of Study Group 4.

### **40. Engage African astronomical society**

African Astronomical Society (AfAS) is a Pan-African Professional Society of Astronomers covering the whole African continent. As an international organization it is eligible to represent the interests of its community in international bodies such as UN COPUOS. Given the involvement of the African community with SKAO, the scientific activities of the AfAS membership will be considerably impacted by the increasing number of satellites in LEO.

Contact with AfAS should be established through its president or the head of its Secretariat.

### **41. Definition of the Agenda for the UN Summit of the Future**

The upcoming United Nations Summit for the Future represents a critical platform for addressing global challenges and opportunities in the coming decades, including those related to space. It is essential for the IAU to support the development of this summit's agenda, advocating for the inclusion of discussions on dark and quiet skies within the broader context of space sustainability.

The IAU is uniquely positioned to highlight the importance of protecting dark and quiet skies. By doing so, the organization can contribute to a more holistic approach to space sustainability at the UN Summit for the Future. The summit, being a high-profile global forum, offers an unparalleled opportunity to bring these issues to the forefront of international policy discussions. By influencing the agenda, the IAU can help ensure that measures to protect dark and quiet skies are integrated into broader strategies for sustainable space exploration and utilization.

To effectively support the development of the agenda, the IAU could consider the following possible actions and next steps:

1. Identification of key contacts: The IAU could start by identifying the individuals and departments responsible for the summit's discussions and agenda-setting within the UNOOSA in Vienna and at the UN's main offices in New York. This involves pinpointing those in charge of space-related topics, specifically those focusing on sustainability and environmental impacts.

2. Establishing communication channels: Once the key contacts are identified, the IAU could establish direct communication channels with these individuals or groups. This can be initiated through formal letters, emails, or setting up meetings, expressing the IAU's interest in contributing to the summit's agenda.
3. Presenting expertise and proposals: The IAU could prepare a detailed proposal outlining the importance of including dark and quiet skies in the space sustainability dialogue. This proposal could highlight the IAU's expertise in this area and how it can contribute valuable insights and data to the summit discussions.
4. Collaboration and partnership building: Seeking collaborative partnerships with other organizations and entities that have a vested interest in space sustainability and the protection of dark and quiet skies could strengthen the IAU's position. This could include academic institutions, environmental groups, and other international space organizations, such as SGAC.
5. Participating in pre-summit events and activities: This involvement could provide a platform for the IAU to raise awareness about the importance of dark and quiet skies and to integrate this topic into the broader agenda of the summit.

## **42. Partnership with the Space Court Foundation**

The Space Court Foundation (SCF) is well-positioned to offer insights on how astronomical observations intertwine with the legal aspects of outer space use and exploration. Our team, consisting of experienced space lawyers and passionate legal interns, is equipped to analyze complex interactions from both international and national legal perspectives.

A partnership with SCF holds significant potential for mutual benefits, leveraging the strengths of each initiative to advance common objectives.

**Enhanced Research Capabilities:** The collaboration would empower IAU CPS by tapping into SCF's expertise in conducting comprehensive legal and policy research. This synergy will focus on exploring the ways in which space regulations and laws can contribute to the protection of D&QS.

**Youth Engagement and Problem Resolution:** SCF, with its commitment to fostering the involvement of the younger generation (internship programme), can play a pivotal role in addressing and resolving the pressing issues of orbital light pollution and the safeguarding of astronomical observations. This collaboration would provide a platform to inspire and educate the youth on these critical matters.

**Social Media and Engagement Activities:** Both organizations stand to gain from joint efforts in social media campaigns and engagement activities. Webinars, workshops, podcasts, and video series focused on pertinent issues would amplify the reach and impact of our collective message.

**Moot Court Competition Involvement:** SCF is one of the organizers of the IISL Moot Court Competition. This year's competition question directly addresses legal issues around D&QS,

where students will delve deeper into the intricacies of D&QS protection. SCF collaboration can facilitate a more detailed exploration of these topics within the framework of the competition.

Network Expansion: SCF's established connections with major international legal firms and space law organizations can be instrumental in disseminating the principles of D&QS across diverse communities and sectors. This expanded network will contribute to a broader understanding and adoption of these crucial concepts.

As we move forward with this collaboration, it is imperative for us at SCF to maintain our independent stance, ensuring that our contributions are both sustainable and mutually beneficial. While we are enthusiastic about this partnership, we are also mindful of the need to balance our involvement, ensuring that our efforts are appropriately valued and respected.

#### **43. IISL Moot Court Competition 2024**

The International Astronomical Union (IAU) could consider providing support to students participating in the IISL Space Law Manfred Lachs Moot Court Competition 2024, especially as the theme this year aligns with the protection of dark and quiet skies and the freedom of scientific investigation. This support is pivotal for the development of interpretations within space law that harmonize with the understanding of astronomical observations as a fundamental form of using and exploring outer space. By reinforcing the notion that safeguarding dark and quiet skies is integral to the freedom of scientific investigation and the freedom of use and exploration, the IAU could play a key role in shaping the legal discourse around the Outer Space Treaty's applicability to this issue for the Moot Court and possible beyond. Additionally, the IAU could advocate for the use of other space law tools, such as liability protection, to preserve the integrity of dark and quiet skies in that context.

To operationalize this support, the IAU could:

- Inform the International Institute of Space Law (IISL), the organizer of the Manfred Lachs competition, about its intentions to contribute.
- Organize webinars for participating students, providing technical and legal guidance in the formulation of their written and oral memorials. It would be critical to conduct these webinars in various time zones to ensure equitable access and eliminate any undue advantage for specific groups.

By actively engaging with students in the Manfred Lachs competition, the IAU could foster a deeper understanding of the intersection between space law and the protection of dark and quiet skies, influencing the next generation of legal scholars and practitioners in space law.

#### **44. Further explore a liability claim (“damage”)**

As explained in the discussion paper, though this option is attractive to countries that possess major observatories, victory is unlikely due to the narrow definition of damage in the 1972 Liability Convention and the requirement of compliance by parties to the outcome of the claim.

However, a liability claim could be useful after a successful ICJ advisory opinion (or in parallel with) that would clarify questions that could have hindered a liability claim. Moreover, even if unsuccessful, a liability claim could draw publicity and attention to the issue of light pollution and spark further discussion at UN COPUOS or even the General Assembly.

#### **45. Bring allies from outside astronomers (not patronizing/ivory tower)**

Many people are aware of the problem of satellite pollution, but see it as a problem only for research astronomers. Conversely, most of the research astronomers who are aware of this problem and are fighting for it are deeply embedded in the rather exclusive system of academia. How do we privileged academics respectfully reach out to activists like environmentalists and Indigenous knowledge keepers who are already fighting other battles? There are so many aspects of this fight for regulation in LEO that match similar pollution fights in the past, there is a lot we can learn. The community that has been studying and fighting artificial lighting for years may be the best place to start networking and bringing in allies, as we have a lot of overlap, but they have a few decade head start on us, and overlap more with environmental activists.

#### **46. An international letter on astronomy as the exploration and use of space OR in support of ASTRO-ICJ (consider which makes most sense)**

This action item would involve drafting an open letter similar to those released by the OSI on reducing risks from uncontrolled reentries of rocket bodies, and on kinetic anti-satellite (ASAT) testing. An open letter has the benefit of being a centralized document that can be referenced and promoted by the diversity of relevant state and space actors, including but not limited to astronomers/astronomical societies like ESO, IDA, IAU, and SKAO, the ITU, environmental NGOs like UNESCO and UNEP, COPUOS, academic institutions, and industry members like satellite companies. If the open letter focuses on declaring astronomy as the exploration and use of space, it can serve as an official statement by these actors in connection with D&QS issues. It can thus be referenced in public communications, and engagement with policy makers and satellite companies.

The letter may then be leveraged as a starting ground for the ASTRO-ICJ initiative, or similarly as evidence for international support of astronomy being considered the exploration and use of space, which can be incorporated into our advisory opinion request. Furthermore, the letter may highlight the states with, as stated in the pre-workshop ASTRO-ICJ strategy paper, “skin in the game to champion” the initiative. Alternatively, we may make the open letter in support of the ASTRO-ICJ initiative itself, which can take place once one or more states decide to champion the initiative and the OSI takes more of a backseat. This timing would serve, among other things, to “provide advice, encouragement, and outside validation.”



#### **47. Answer the question what the sky looks like during a total eclipse**

Millions of people will be looking up at the sky on April 8, 2024 as a total solar eclipse sweeps across North America, including large population centres like Toronto and Montreal. Will they see satellites? Will it be distracting? A naive calculation suggests “possibly”, but we need to run more detailed simulations to check this. If we predict lots of satellites will be visible, we need to use this as a public education opportunity and discuss it as widely as possible.

#### **48. Time big events and publicity (like an eclipse)**

One way to generate publicity and awareness is to coordinate actions and activities around events where people will be thinking of the sky, such as the upcoming 2024 eclipse. There are also anniversaries, such as the five-year anniversary of the first SpaceX (May 23, 2019 initial launch) launch that are natural opportunities to share the full story of the impact.

#### **49. Publish a definitive statement on why all telescopes cannot go into space**

As the astronomy community raises dark and quiet skies concerns, a common response from uninformed members of the public and even in the space sector is to suggest that ground-based astronomy should essentially be abandoned in favour of space-based astronomy. Reasons are given such as the lowering of launch costs, development of better satellite technologies, and the better observing environment in outer space. While there are certainly many scientific advantages to locating observatories in space, there are many practical difficulties, and ground-based capabilities cannot be easily replicated. The IAU CPS could develop materials that definitively outline the pros and cons of space astronomy and the numerous reasons why ground-based astronomy is still required, even in the new space age.

#### **50. Engage with ground-based telecom industries**

Given the general shift in consumer and commercial use of cell phones, the satellite communications industry is making a move to larger satellites that can communicate directly with cellular devices. This overcomes several limitations of terrestrial cellular networks. Space companies are partnering with ‘ground-based’ telecoms partners to broaden the service available to consumers (check examples with SpaceX and AST Mobile). Presumably, these large telecom companies are sensitive to ESG concerns and thus the astronomy community could bring this issue to them. The IAU CPS (industry and policy hubs) could initiate this contact.

#### **51. CPS should create an action and coordination plan (think like a lobbyist)**

The goals of CPS policy efforts are to articulate the negative impacts on astronomy from satellite constellations with clarity for policy makers; to provide a policy framework for mitigations that can be used by advocates for national regulation and UN consideration at the ITU-R and COPUOS; to provide legal and policy analysis to support the recommended framework; and to

provide concise technical guidance for regulatory consideration. Action and coordination therefore mean proactively supplying advocates and policy makers that request support directly with consistent information. One example would be providing a completed and approved document as a push to all the major astronomical societies. Specific possible actions in the near term include

- Finishing the Position Paper, getting IAU Executive Committee approval, submitting it as a resolution for approval at the GA, and providing it on request to space policy regulators.
- Finishing the legal and policy analysis document, refining its policy recommendations, and creating a more finished version of the policy framework started in the Position Paper.
- Polishing the consolidated technical requirements and furnishing them to advocacy groups and policy makers.
- Providing the IAU with positions for their interactions with UN COPUOS, its STSC and LSC, and the Group of Friends.
- Continuing support of development of an astronomy module for the Space Sustainability Rating.

## **52. Contact other scientific disciplines**

The long game of the CPS is to make mitigating impacts on astronomy an essential part of long-term space sustainability. The CPS must therefore articulate astronomical goals specifically and partner with advocates with complementary interests in sustainability. The scientific groups from whom research is needed are orbital dynamicists, atmospheric dynamicists, and atmospheric chemists. (The problem astronomers need to know is how the transparency of the stratosphere will be changed by frequent launches and re-entries. The detailed model clearly needs drag as a function of height, rate of deposition of specific species, rate of circulation and rate of diffusion.) CPS should and will proactively reach out to investigators and their professional societies to stay current with and encourage expansion of such research. We also make the case that visible artificial satellites will disrupt species that rely on celestial navigation; it is therefore incumbent on us to identify such research and have a similar interaction with its practitioners. To the extent that CPS undertakes public outreach and desires to influence public opinion, the guidance of behavioral scientists will be particularly helpful; in that case, making contact with individuals would be the most effective beginning. It goes without saying that close involvement with the planetary science / solar system science community is critical to making common cause.

## **53. Continue to work with astronomy picture of the day**

Astronomy Picture Of the Day (APOD) is a website with significant traffic where they showcase the best astronomical pictures through the past 50 or so years. Their user base could be engaged with further to bring attention to the issue of light and spectrum pollution (in addition to what has already been shown on APOD). This could be done with real photos showcasing satellite streaks and/or simulations.

#### **54. Engage the International Astronautical Federation**

The IAF is an international space advocacy non-governmental organization aimed at facilitating international space cooperation. They partner with several international organizations (UNESCO, ITU, UNOOSA, ESA) in their activities and organize high-level, very well attended meetings and conferences, including the international space forum at the ministerial level, in which Ministers of University and Research and Space, as well as delegation from Space Agencies and International Organizations are in attendance.

These meetings could be an opportunity to raise awareness and engage national players on the issue of satellite constellations. Contact with IAF should be made through their secretariat team.

#### **55. Give Early Career Researchers Equal Opportunities to Participate**

The roles of early career researchers (ECRs) are too often reduced to media-oriented aspects of advocacy. Progress can often be stunted if career lifetimes are waited out before ECRs are given equal voice in discussions. Instead, experienced professionals should work in tandem with emerging researchers, with both groups recognizing the value in each other's skillsets. What does equal opportunity look like within the Dark and Quiet Skies initiative? It goes beyond simply inviting ECRs to "listen in" on meetings by ensuring that ECRs are continuously included and their voices heard beyond preliminary discussions. Present leaders could delegate larger tasks to people who have not yet had the chance to step up, and should actively listen when concerns are brought up. Ultimately, the mindset of inclusion must stem from the fundamental understanding of value. ECRs in this initiative have technical background knowledge whose specificity is highly meritable and independent of age. Additionally, ECRs might be plugged into communities that could aid in advocacy efforts (e.g. student clubs), and might have relevant expertise from other disciplines through liberal arts education. This should be recognized and leveraged.

#### **56. Get abundance information of space objects from industry**

As we learn more about the impact of satellite reentries on the upper atmosphere, a result of certain materials used in satellite construction, it will be important to identify which materials are harmful and find out how often they are used. Acquiring that information is difficult because satellite operators withhold specifics about satellite design for competitive reasons. There are, however, avenues that could encourage operators to release some information about their systems.

- Eco labeling: Once it is determined which materials are particularly harmful to the upper atmosphere and/or ozone, a list of those materials could be created with information about the impacts. Operators who disclose that their systems either don't contain, or try to reduce the amount of harmful material in their construction, could be awarded with a eco

badge, or something of that nature. Past examples:  
<https://www.ecolabelindex.com/ecolabels/>.

- Approaching operators: operators might also be willing to disclose certain information if approached by researchers with the right questions and a stated cause for investigating for the purpose of research that could also benefit them, e.g., knowing which materials are hazardous to the atmosphere, etc.

## **57. Proposed topic for NASA Hackathon (done by Queen's University)**

NASA Space Apps Challenge is held every year with the purpose of solving existing problems in the fields of Astronomy and Outer Space, Engineering, Biology, Arts (popularization of science), and many more. NASA hackathon participants are people of all ages and backgrounds. NASA Space Apps Challenge is a great platform to share our concerns about D&Q Skies and engage participants to solve the problems.

As a first step, we could contact organizers asking if the protection of D&Q Skies (and atmospheric pollution from satellites) could be posted as a problem for the next NASA Space Apps Challenge.

D&Q Skies problems can be assigned under scientific problems or arts (science popularization) sections. Examples of potential problems are:

- a. Create a satellite design that will reduce the light pollution from the satellite;
- b. Design the technology that will reduce the 'loudness' of the satellites detected by radio telescopes;
- c. Disposal of satellite remnants is designed in a way that the whole satellite should be burnt in the atmosphere. This method has several drawbacks. Some parts of the satellite can survive the burn-up and create a dangerous situation on the land or pollute the water. Also, elemental mass flux from the satellite in the atmosphere exceeds the metal income from natural sources (meteoroids) polluting the atmosphere. Designs another way of satellite disposal procedure.
- d. Create a video/simulation to educate the general public about light and radio pollution; (Example of public awareness challenge: <https://2021.spaceappschallenge.org/challenges/statements/unlocking-the-secrets-of-the-sun>);
- e. Visualize how much astronomical data is affected by satellites (it can be a website with photos, an app, etc.); (example of STEM and art challenge combination <https://2022.spaceappschallenge.org/challenges/2022-challenges/steam>);
- f. "Translate" the radio pollution into the audio recording

NASA hackathon already posted a problem about Mapping space trash in real-time.

## **58. Don't forget the Historians!**

Historians across the subfields of history of science and technology and legal history are uniquely trained to understand the cultural history of legal, scientific and technical change over time. Historians can offer suggestions for more ethical approaches to the use of new technologies in commons spaces through analysis of past analogs. Those holding curator and editorial roles are in a unique position to inform the general public of present and historical concerns of the observational astronomy community through public histories, exhibits, and the generations of easily digestible articles across social media and other periodicals. Topics for these products could cover how observational astronomy has evolved with the introduction of new ground-based and sky-based technology, and challenges experienced along the way. Historians can also lend their knowledge to directly advocate for dark and quiet skies including how this issue is entangled with evolving laws. Therefore, we could:

- Arranging for seminars where astronomers can alert historians to the issues surrounding dark and quiet skies
- Astronomers and historians collaborating to write public facing articles concerning dark and quiet skies
- Historians contributing to amicus briefs that require legal historical analysis to support dark and quiet skies

## **59. Engagement with UNOOSA (Space Law > Capacity Building > Space Law Curriculum)**

It is of critical importance for the International Astronomical Union (IAU) to expand its collaboration with the United Nations Office for Outer Space Affairs (UNOOSA) beyond the Committee on the Peaceful Uses of Outer Space (COPUOS) meetings and committees, particularly within the realm of space law. An excellent avenue for such collaboration could involve lending support to the update of the Space Law curriculum currently accessible on the UNOOSA website. Given the ever-evolving landscape of space activities and the increasing importance of space sustainability, it becomes important to integrate crucial elements pertaining to the protection of dark and quiet skies into the curriculum. Through the provision of expertise and resources, the IAU can make significant contributions to shaping a curriculum that accurately reflects contemporary challenges and advancements in space law. This effort ensures that the upcoming generation of space professionals is adequately prepared to tackle issues related to preserving the outer space environment. This collaborative initiative extends beyond the routine interactions at COPUOS, thereby strengthening the connection between astronomy, space law, and the promotion of sustainable practices within outer space activities.

## **60. Work better with Indigenous peoples**

Indigenous peoples have cultural, societal, and economic interests in the use of outer space. Those interests are complex, vary between nations and peoples, and should not be assumed to align with any one group, e.g., astronomers. Astronomers have focused largely on cultural

heritage when referencing Indigenous peoples, but this has implied to many that Indigenous peoples only have an interest in preserving past practices. Astronomers should avoid simplistic arguments that fail to acknowledge the rich diversity among Indigenous peoples worldwide. They should also take actions that are consistent with the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). (This paragraph was written by non-Indigenous individuals).

### **61. Dark and quiet sky month; Near-space environment day; Coordinate the “days” into a broader, structured event; Use existing days and awareness initiatives**

There are multiple awareness initiatives focused on various aspects of the environment, including near-Earth space. We should seek opportunities to incorporate dark and quiet sky programming into these existing events. We do not necessary want to create our own “day” for awareness due to saturation of such initiatives already. Incorporation into Earth-day activities could be a large advancement.

### **62. Ensure there is a Light pollution panel at PDC 2025**

Planetary defence is one of the principal concerns cited for the need to mitigate light pollution. Yet, it is discussed only along the periphery at planetary defence conferences, being brought up by astronomers—and answered by planetary scientists or policy experts with little knowledge of the concern. A panel at the 2025 Planetary Defence Conference (PDC 2025, likely in South Africa) could dive into the issues, bring the concern to the attention of potential scientific and policy allies, and generate additional media.

Michael and Aaron can approach the organizers of PDC 2025 to pitch the idea.

### **63. Re-engage UNESCO on statement**

UNESCO (United Nations Educational, Scientific and Cultural Organization) has long concerned itself with outer space issues, for instance by hosting a 1969 meeting on the legal issues associated with space communications. UNESCO is also one of three partners (along with the Government of Italy and the International Atomic Energy Agency) operating the Abdus Salam International Centre for Theoretical Physics near Trieste. Much of UNESCO’s early engagement on outer space was led by Frank Malina, the first director of the Jet Propulsion Lab at CalTech, who worked for the international organization from 1947-1953.

One of the more promising avenues that the astronomical community might wish to pursue at UNESCO is the adoption of a “statement” by the organization. An example is the “Seville Statement on Violence”, adopted by an international meeting of scientists that had been convened by the Spanish National Commission for UNESCO in 1986 and subsequently adopted

by UNESCO at the twenty-fifth session of its General Conference in 1989. The statement was designed to refute “the notion that organized human violence is biologically determined”.

Given that Spain has major interests in astronomy, it might make sense to pursue the same Spanish National Commission for UNESCO about this idea. Do we have a Spanish colleague who could explore the possibilities here?

#### **64. Engage United Nations Environmental Programme on sky and Earth-Space environmental studies**

The United Nations Environmental Program (UNEP) has led the adoption of highly effective multilateral treaties on chlorofluorocarbons (Vienna Convention on the Protection of the Ozone Layer and its Montreal Protocol), persistent organic pollutants (Stockholm Convention), and mercury (Minimata Convention). UNEP is now working toward a multilateral treaty on plastic pollution, including in the marine environment. Given the parallels between the ocean plastic crisis and the multiple crises associated with megaconstellations (debris, atmospheric chemistry, climate impacts, light and radio interference with astronomy, impacts on wildlife, etc.), it may be possible to steer UNEP toward the protection of the Earth-space environment.

#### **65. Outside voices and celebrities**

Celebrity involvement is a tried and tested strategy in international campaigns for policy change. Consider Princess Diana and the successful effort to ban antipersonnel landmines, or the longstanding use of “Goodwill Ambassadors” by the United Nations. There is even a widely cited book on the topic: Andrew Cooper and Louise Frechette, *Celebrity diplomacy* (Routledge, 2015) (Note: Frechette knows her stuff, having served as Under-Secretary General of the UN for eight years).

Astronomers should actively seek celebrity support. Such support could take many forms, up to and including the threat to the night sky as a theme for a new song ....

#### **66. Use astronomical facilities to advertise the issue**

There are close to 1000 astronomical observatories in the world (approximately 350 in the United States alone, with some 600 in other countries) which in total makes for a widespread global footprint of observatories, in addition to other related astronomical facilities. Although many are situated in remote locations, given their often recognizable and unique architectural structure, they are frequently photographed installations. This represents a potential opportunity of a coordinated global marketing campaign to bring concentrated public and government attention to this issue, with the ability to emblazon a single slogan or message on as many of these astronomical structures as practicable. The additional possibility of a single, easy to

remember URL to accompany this slogan, where more information on this issue can easily be obtained, may also be worthwhile.

## **67. Ally with the International Institute of Space Law**

For over 60 years the International Institute of Space Law (IISL) has served as the premier global professional body for lawyers engaging with outer space, both internationally and within their respective domestic jurisdictions. Its institutional and individual elected membership today spans some 50 countries and it recently released in July 2023 its 110-page final report on 'Keeping the Night Sky Clear: IISL Working Group on the Light Pollution of the Night Sky from a Space Law Perspective'. In March 2023 the IISL, in collaboration with the European Centre for Space Law (another potential partner), hosted its annual space law symposium on the opening day of the COPUOS Legal Subcommittee on 'Legal Aspects of Dark and Quiet Skies'. Furthermore, the 2024 problem for the IISL's Manfred Lachs Space Law Moot Court Competition is focused on this same exact issue, with the final of this global competition in October 2024 to be adjudicated in Milan by three sitting judges of the International Court of Justice (who also usually attend the IISL's awards dinner the same evening). Accordingly, the IISL is already highly focused on issues of shared concern, which coupled with an existing crossover of membership (with scope to expand this even further), represents a key potential partner for pursuing collaboration and shared initiatives. This is particularly the case if pursuing an International Court of Justice advisory opinion, as to lack the IISL's support for this endeavour would likely represent a powerful criticism levelled by detractors.

## **68. Other Possible Action Items**

- Continued activism among potential flags of convenience
- Contact environmental and behavioral science groups
- Clarify the relationship between the CPS and industry
- Build the relationship between astronomy and industry
- Develop an executive briefing for leaders in the aerospace industry
- Include space environment in the classroom
- Be disruptive (and annoying)
- Engage the G21
- Engage COSPAR
- Contact amateur astronomy organizations; and Contact science and technology communities