Dark Skies Policy Consultation: response from the Royal Astronomical Society

1. This is the official submission from the Royal Astronomical Society (RAS) in response to the All-Party Parliamentary Group for Dark Skies consultation.

2. The RAS represents more than 4,400 astronomers and geophysicists, in the UK and around the world, in occupations in academia, industry, education and public engagement, and journalism, as well as others in the wider economy. Our members are described as 'Fellows'.

3. This response was shaped by input from our governing Council, and our policy group consisting of RAS Fellows in industry, universities and research establishments.

Executive Summary

4. The RAS broadly supports measures to control terrestrial light pollution to enable widespread public access to dark skies, noting the inspiration it provides, particularly in encouraging learners of all ages to consider careers in STEM. APPG members should note our previous evidence on this for the Science and Technology Committee back in 2003[1], and in more recent consultations on planning policy[2]. To a large extent our arguments relating to this remain the same today.

5. Amateur astronomy groups are well placed to describe the impact of terrestrial light pollution, notably our colleagues in the Commission for Dark Skies[3], so in this submission we concentrate on a different and more recent issue, namely the impact of satellite 'megaconstellations'.

6. These systems, being deployed and planned by companies around the world, including OneWeb in the UK, will inevitably have a detrimental impact on professional astronomy and space science.

7. The work of amateur astronomers is affected too, and without proper design and licensing controls, these systems will have a significant impact on the public view of the night sky for virtually the whole of the inhabited world.

8. We offer a series of recommendations for the UK government, as a part owner of the OneWeb system.

Megaconstellations

9. It is now 63 years since the launch of the first artificial satellite. The science of astronomy has benefited immeasurably from their deployment, for example in data from orbiting observatories like the Hubble Space Telescope, and in the fields of X-ray and gamma-ray astrophysics that are impossible to carry out on the ground.

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[1] https://ras.ac.uk/sites/default/files/2018-07/Light%20Pollution%20-oral%20evidence.pdf
[2] https://ras.ac.uk/sites/default/files/2018-07/National_Planning_Policy_Framework_consultation.pdf
[3] https://www.britastro.org/dark-skies/

10. Until 2019 there were an estimated 2,000 satellites deployed in low Earth orbit (LEO), defined as the region of space up to 2,000 km altitude. This number of objects were an occasional nuisance for imaging the sky, but in general the astronomy community was sanguine about them.

11. This changed with the decision by SpaceX, and several other companies, to deploy so-called 'megaconstellations' in LEO. To give members of the APPG an idea of the scale of the change, the SpaceX Starlink system alone, operating at 550 km, has licences for a total of 42,000 satellites[4]. Planned deployments include those by OneWeb[5], Amazon Kuiper[6], Boeing, Samsung, and the Chinese space agency, which could see more than 100,000 satellites placed in orbit by the end of the decade.

12. The new constellations are primarily intended to provide communications networks, with for example Starlink offering broadband Internet access. After its £400m purchase of a share in the OneWeb system[7] the UK government is considering how its satellites can fulfil UK communication and navigation needs.

Impact on professional optical astronomy

13. If a satellite illuminated by sunlight crosses the night sky, it appears as a moving point of light. The brightness of the satellite depends on the reflectivity of the material it is constructed from, its altitude and its orientation with respect to the Sun and the observer.

14. Satellites contaminate an image made with an astronomical telescope, with the moving point creating a streak across the frame. There are software mitigation techniques to mitigate this, such as stacking multiple images, but this will become far more difficult if and when all the new constellations are placed in orbit – many scientific targets will inevitably be affected and data will be lost. Mitigation software also requires investment, and is an additional overhead for researchers and the agencies that support them.

15. Models by researchers at the European Southern Observatory[8] and at MIT[9] quantify these effects as being particularly serious for telescopes studying wide areas of the sky, such as the Vera Rubin Observatory now under construction in Chile, with the UK as a partner. Starlink satellite trails may appear in more than 50% of its twilight image frames. The OneWeb constellation will be deployed at 1200 km, with an application

[4] See e.g. https://fcc.report/IBFS/SAT-LOA-20200526-00055/2378669 and https://fcc.report/IBFS/SAT-LOA-20170726-00110/1252847 and other filings to the US Federal Communications Commission
[5] https://www.oneweb.world/media-center/oneweb-seeks-to-increase-satellite-constellation-up-to-48000-satellites-bringing-maximum-flexibility-to-meet-future-growth-and-demand
[6] https://blog.aboutamazon.com/company-news/amazon-receives-fcc-approval-for-project-kuiper-satellite-constellation
[7] https://www.gov.uk/government/news/uk-government-to-acquire-cutting-edge-satellite-network
[8] https://arxiv.org/pdf/2003.01992.pdf
[9] https://arxiv.org/pdf/2003.07446.pdf

to place a further 1200 satellites at 8500 km[10]. These will be visible throughout the night during the summer months, making mitigation significantly harder.

16. APPG members should note that this will be detrimental to areas of science where the UK is world-leading, including in the detection of planets around other stars, the follow up of gravitational wave events, and the detection of potentially hazardous near-Earth objects. All of these are transient phenomena, so are affected by even short interruptions to the operation of observatories.

Impact on amateur astronomy and the night sky

17. The first Starlink satellites were bright naked eye objects, particularly after launch, and led to significant public interest in the 'string of pearls' seen where around 60 spacecraft appear in a train moving across the sky. SpaceX now include a 'visor' on each satellite to reduce its apparent brightness, reported now to be below the limit for the naked eye[11], and are working with astronomers to reduce the brightness of each satellite as it is raised to deployment altitude, and when it lowers to deorbit.

18. There are nonetheless many example images demonstrating the impact of Starlink on the night sky, including those of the recent bright comet NEOWISE[12]. Amateur astronomers are also much less able to mitigate the impact of satellite trails than their professional peers.

19. In addition, the RAS strongly believes that this is an issue for the wider public, who have the right to enjoy an unfettered view of the night sky, as much a part of our natural heritage as terrestrial landscapes. During the pandemic the necessary restrictions on movement led to greater interest in astronomy (covered by news media in the spring), and the public would likely not welcome a further systemic change that hinders this.

Policy recommendations

20. Satellite megaconstellations are launched by companies under the licencing organisations in individual nations, in the case of the US the Federal Communications Commission, and in the UK Ofcom. At present these licences do not consider the impact of satellites on the night sky, or on scientific research. Satellite networks are also registered with the International Telecommunications Union, which again does not include the impact on the night sky or astronomy in its remit.

21. As an overarching recommendation, we commend the work of the US-led SATCON workshop to APPG members, as this has a series of detailed proposals for the scientific community, satellite operators and policymakers.

[10] https://docs.fcc.gov/public/attachments/FCC-20-117A1.pdf
[11] http://www.satobs.org/seesat/Sep-2020/0023.html
[12] https://www.sciencealert.com/yep-starlink-totally-photobombed-a-beautiful-image-of-comet-neowise

22. The UK has a specific opportunity to meet the standards set out for mitigation, given its purchase of a share in OneWeb. Our recommendations for the UK government, already conveyed to the UK Space Agency, are as follows:

i. The Science and Technology Facilities Council / UKSA / both need to commit to financial resources for research into the impact of megaconstellations on optical facilities, not least as the UK government is investing in new facilities that will be directly affected. This work is happening, but is very much a spare time effort and, therefore, unlikely to be sustainable. Resources could pay for one or more postdocs under the supervision of people based at or heavily involved with observatories.

   This work should at least eventually include observational campaigns, to add to the dataset on how changing design for deployed satellites is working, and to assess this from different geographical locations. Alongside existing constellations, another aim would be to develop a means of assessing the impacts on optical astronomy of future systems seeking a UK operation licence.

   UK research also needs to be carried out in collaboration with international partners such as AURA and NOIRLab in the United States, and should complement their efforts.

ii. The current UK government consultation on "Spaceport and spaceflight activities: regulations and guidance" (see https://www.gov.uk/government/consultations/spaceport-and-spaceflight-activities-regulations-and-guidance) should include the effect on ground- and space-based astronomical facilities. The RAS will respond to the consultation to that effect in the near future, and we will urge stronger domestic regulation on satellite design and deployment.

iii. The UK government should in the medium-term work to strengthen the international regulatory framework through UN bodies like COPUOS, to include the impact on ground- and space-based astronomy.

   We recognise the difficulties of updating or replacing the Outer Space Treaty, given the risk that a weaker regulatory framework might result. However, there is an opportunity for the UK to lead on better guidelines, shaped by both academic research and examples of mitigation measures deployed by existing operators. We would urge UKSA not to acquiesce to weaker guidance, simply as a result of the constellations already deployed being ‘facts in the sky’.

iv. With the government purchase of OneWeb, the UK Space Agency has a particularly important role to play with that operator, and we urge the government to ensure that future OneWeb satellites are deployed in a way that minimises disruption to astronomy.

For example, although the design of individual satellites is different to that in the SpaceX constellation, they could use similar technology to substantially reduce their observed brightness. OneWeb should also carry out bidirectional reflectance distribution simulations to support observations, and share positional information to allow observatories to better schedule imaging.

OneWeb is also distinct from Starlink in its operation at 1200 km. Its satellites will be visible throughout the night in the summer months, affecting many mid-latitude observatories. We therefore support the SATCON recommendation that new deployments should not be above 600 km.