Industry and Technology Hub

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

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The Optical/Infrared Astronomy Concern with Satellite Constellations

- Low-orbiting satellite constellation projects are proliferating now, with tens of thousands of satellites proposed to deliver broadband, earth imaging and other useful services
- Satellites operating at lower altitudes can be seen by observatories and may impair optical and infrared astronomical science
- Spacecraft at lower altitudes typically spend extended periods in sunlight over regions in darkness, making them even more visible
- Options to mitigate the visibility of these satellites is constrained:
  - Spacecraft surfaces are usually reflective for thermal reasons
  - Spacecraft orientation is limited for operational reasons
  - Observatories cannot frequently schedule around satellite passes
- Successful technological and operational solutions have been identified through collaboration between astronomers and the satellite industry, but are still in the early stages of development

The IAU Centre

- Further progress requires collaboration between the satellite and astronomical communities to identify and apply mitigations to the impact of satellites on the dark and quiet sky
- The International Astronomical Union (IAU) proposed a forum for this purpose: The IAU Centre for the Protection of the Dark & Quiet Sky from Satellite Constellation Interference" (CPS)
- The Centre was established on April 1, 2022 to offer resources, collaboration and encouragement for voluntary action from both industry and astronomy
- Co-hosts of the Centre are:
  - NOIR-Lab, a U.S. center for ground-based optical astronomy funded by the National Science Foundation (NSF), and
  - the SKA Observatory (SKAO), a UK-based intergovernmental organization building the world's most powerful network of radioastronomy telescopes
- 4 Hubs: Industry Hub, Satellite Hub, Community Engagement Hub and Policy Hub.

Industry Hub: Building the Collaboration between Satellite & Astronomy Communities

The “Industry Hub” was one of 4 established within the IAU Centre, and is meant to engage the technical insights of both satellite stakeholders and astronomers to build the tools and resources to spur voluntary adoption of mitigations

- Most space operators are committed to being good stewards of space, but require familiarization with the effect on astronomy, and tools to assess their project and to evaluate mitigations
- Operators are more likely to voluntarily adopt best practices that are well-defined, with performance-based metrics that leave room for customization and innovation
- Mitigations are more likely to be incorporated if integrated early in the satellite project life-cycle, avoiding prohibitive delays and costs from retrofitting or change orders

Industry Hub Objectives

- Raise Awareness within satellite community that constellations and even smaller satellites have potential to adversely impact astronomy
- Foster technical collaboration across stakeholders - private satellite sector, government and astronomers
- Promote development of tools for satellite operators to predict and assess visibility of their systems, prior to launch and after
- Further develop best practices and mitigations to reduce visibility, and share lessons learned
- Encourage satellite operators to commit to and adopt the known best practices and mitigation techniques to reach the target brightness

Scope of Satellites with Potential to Impact Astronomy

Primary Focus: Low-earth orbiting (LEO) constellations with satellites weighing >100s of kg typically exceed the practical brightness limit of 7th mag.

- Broadband / communications constellations deploying in large numbers, often with large surface areas. Many of the earliest to deploy already working with astronomers.
- New remote sensing constellations with larger satellites ~100 kg

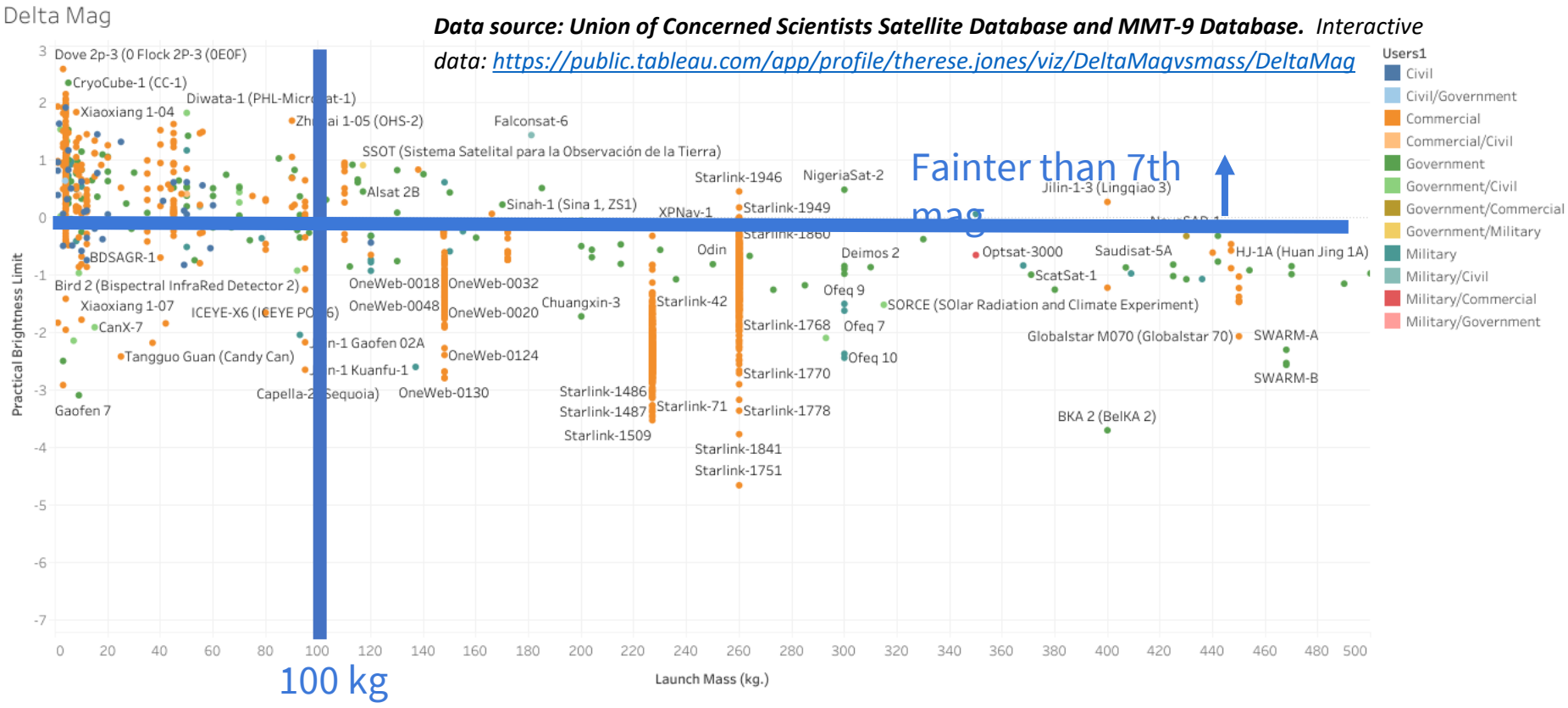
Additional Inquiry: Smaller satellites may also exceed the practical brightness limit

- Commercial remote sensing constellations weighing 10s of kg with hundreds of satellites are likely fainter, but may exceed the brightness limit
- Individual cubesats are not all below the brightness limit

Challenges in engaging with diverse satellite operator community:

- Early stage of testing mitigations and best practices
- Need clearer assessments of which satellites are of concern or not
- Limited predictive tools to assess designs, prototypes
- Uneven ability for satellite operators to iterate in design to adopt mitigations
- Varying priorities across national governments authorizing or commissioning constellations
- Evaluating which constellations merit engagement, which are not yet ripe/serious
- Keeping up with ongoing growth in constellations commercial & government interest in disaggregated architectures and smaller satellites

Satellites in the 100+ kg range typically exceed the 7th magnitude threshold for astronomers, but many smaller sats do as well



Industry Working Group

Further work is needed to mitigate impact

- The most effective best practices – and those most likely to be voluntarily adopted by industry – are well-defined, with performance-based metrics that leave room for customization and innovation.
- For widespread adoption pre-deployment, **predictive tools** must be accessible and affordable, including:
  - **Ground laboratories** that can test satellite prototypes using Bi-directional Reflectance Distribution Function (BRDF) measurements
  - **Modelling software** for satellite manufacturers that can assess visibility in design/test stage
  - Further **basic research on reflectivity** of spacecraft materials and designs
  - **Software applications** for the general astronomy community to identify, model, subtract, and mask satellite trails in images

Thank you for your kind attention!