Examples of Optical Astronomy Coordination Requirements in Satellite Authorizations

Image credit: NSF's NOIRLab

Merissa Velez, Federal Communications Commission
Ashley VanderLey, National Science Foundation

Services provided by satellites in low-Earth orbit and ground-based astronomical observations benefit all of us

Image credit: Planet Labs PBC

Interacting galaxy pair NGC 5394/5 with 42 min exposure from NSF's NOIRLab Gemini North 8-meter telescope
Image Credit: Internatonal Gemini Obsrevatory/NOIRLab/NSF/AURA

U.S. Federal Communications Commission Satellite Authorization Process

- In the United States, the U.S. Federal Communications Commission (FCC) licenses the operations of U.S. commercial satellites. It also processes requests for access to the U.S. market by non-U.S. satellite operators.
- As part of its regulatory review the FCC considers whether the "public interest" would be served.
- To help ensure that license grants are in the public interest, the FCC has included conditions in several satellite constellation licenses to address the impact of the constellations on optical astronomy.

FCC Example Grant Conditions Excerpt: License for Kuiper Satellite Constellation

- The operator is required "to continue to coordinate and collaborate with NASA to promote a mutually beneficial space environment that would minimize impacts to NASA's science missions involving astronomy and to coordinate with NSF to achieve a mutually acceptable coordination agreement to mitigate the impact of its satellites on optical ground-based astronomy."
- The license also requires the constellation operator: "submit an annual report to the Commission, by January 1st each year, covering the preceding year and containing the following information: (1) whether it has reached a coordination agreement with NSF addressing optical astronomy; and (2) any steps . . . taken to reduce the impact of its satellites on optical astronomy, including but not limited to darkening, deflecting light away from the Earth, attitude maneuvering, and provision of orbital information to astronomers for scheduling observations around satellites' locations."

Coordination goals with the U.S. National Science Foundation

- Understand challenges to astronomy and impact of various mitigations
- Agree on best practice guidance: achievable now and future goals
- Determine a baseline (modeling and observations)
- Evaluate progress towards reaching target metrics
- Encourage development of innovative solutions in both satellite and telescope technology
- Maintain an ongoing collaboration between industry and science

We greatly appreciate the work being done by the IAU CPS and its satellite industry partners in the Industry & Technology Hub

Sample of Best Practice Guidelines: IAU Technical Studies and Recommendations

See https://cps.iau.org/ for Consolidated Recommendations and Best Practices and other resources; Industry & Technology Hub an excellent place for satellite owner-operators to exchange information and lessons learned.

NSF has been encouraging companies to follow the recommended best practices.

Research is ongoing and we expect the recommended best practices to evolve over time.

Brightness Mechanisms

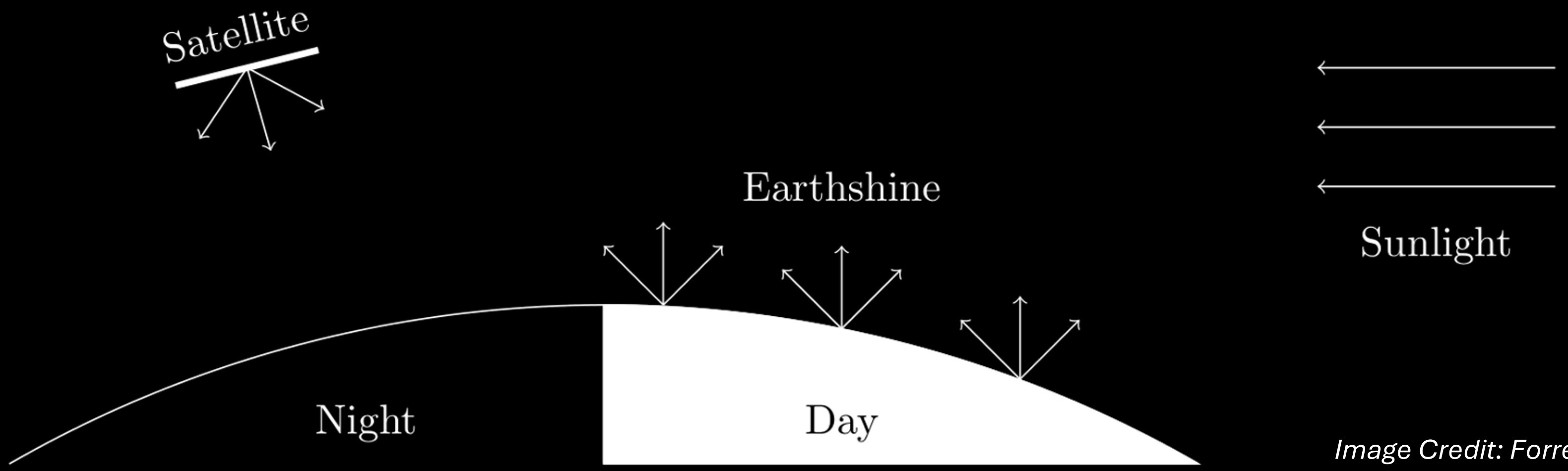

Image Credit: Forrest Fankhauser

- Satellite size: Even very small objects (e.g., the size of a sheet of legal paper) at 550 km altitude would be at 7th magnitude without mitigations. Both large (100 kg+) and small satellites (1 – 10 kg) are observed to exceed 7th magnitude brightness.
- Constellation size: Required coordination with NSF now includes large and smaller constellations.

Optical Facilities have different size fields-of-view

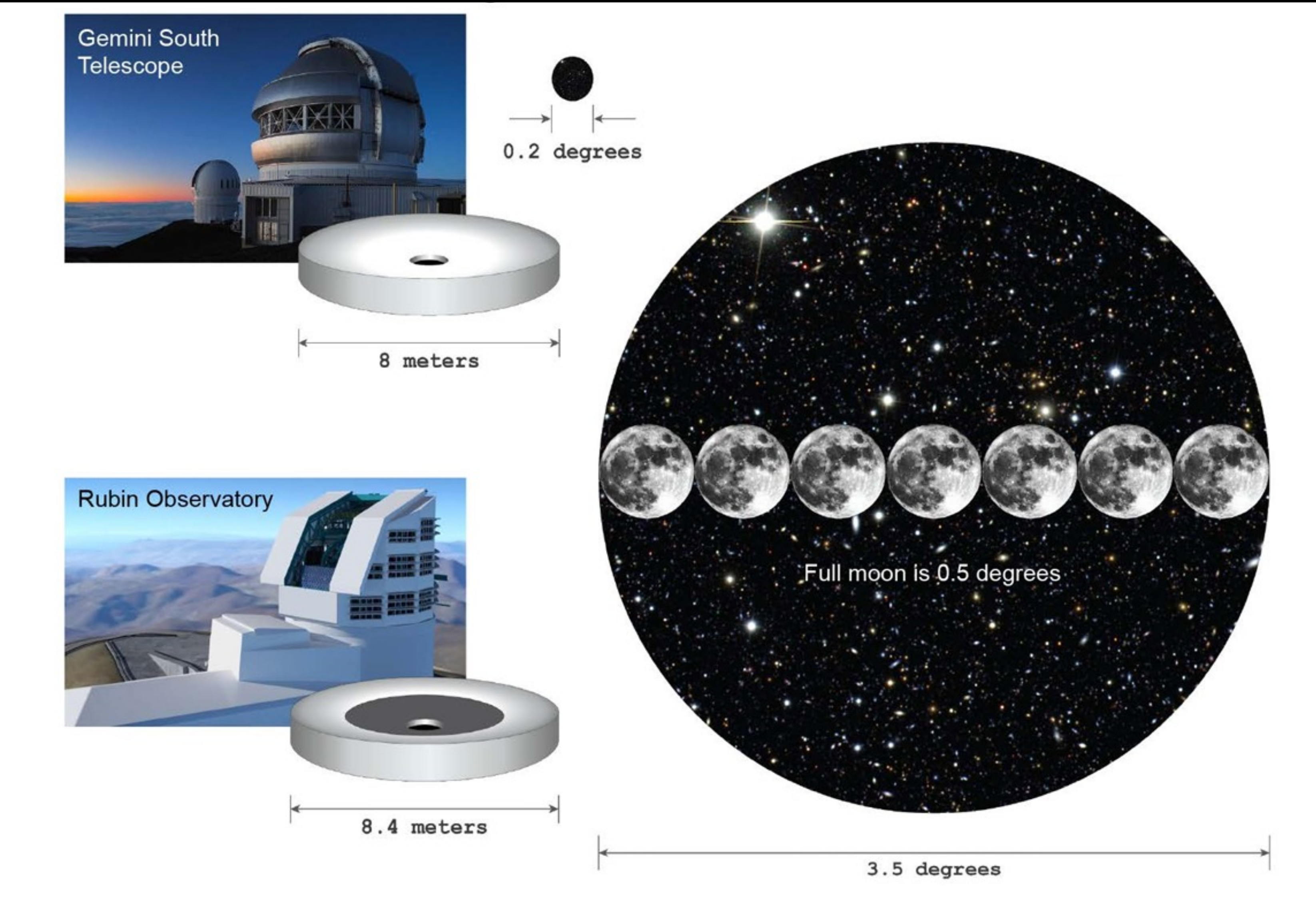

Image Credit: Rubin Observatory Information Booklet; rubinobservatory.org

Wide Field Optical Facilities

+Mitigation: Reducing apparent brightness of satellites in sky to avoid saturation and non-linear effects

–Less effective for faint or single objects; e.g., with spectroscopy

Other challenges include streak masking residuals, variability and glints

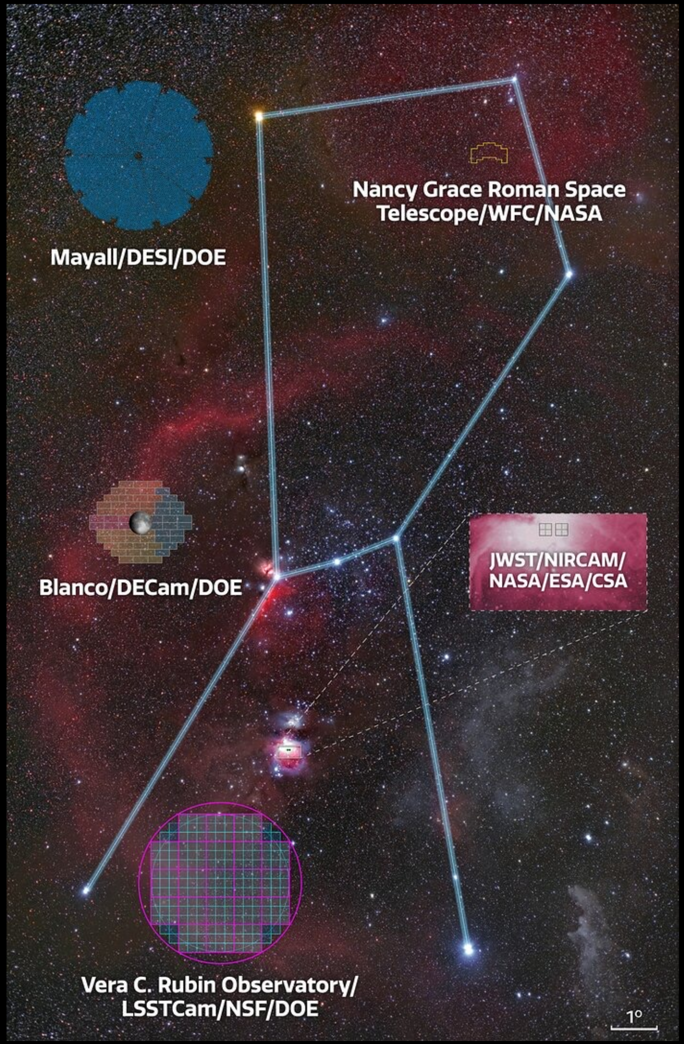

Image Credit: NOIRLab/NSF/AURA/Z. Bardon/J. Pollard

Example successful outcome:

Several companies have taken steps to modify spacecraft designs to reduce brightness: e.g., Amazon Kuiper recently launched a prototype satellite with mitigations to reduce brightness for astronomy to compare with an unmitigated prototype.

Narrow Field Optical Facilities

+Mitigation: Precise orbital telemetry can aid in scheduling to avoid ruining a long integration

–Longer time to complete large surveys

Orion Nebula observation; 208-minute integration
Image Credit: A. H. Abolfath / noirlab.edu

Example successful outcome:

Several companies now providing their orbital ephemerides, including operators of smaller-sized constellations:
e.g., Planet Labs PBC operates approximately 200 earth imaging satellites and makes its ephemerides data available on its website.

https://ephemerides.planet-labs.com/

Progress to Date

Coordination Agreements include commitment to ongoing communication and collaborative problem-solving

NSF currently working with several satellite owner-operators:

- Varying constellation size ranging from larger systems in the 1,000s range to smaller systems in the 100s range and below
- Two signed agreements; four in progress
- Accomplishments include commitment from companies to provide telemetry, design and operational modifications to darken appearance, and development of new materials.

Agreements list a number of best practices for mitigation and a commitment to work towards them.

Research and Development Needs

U.S. is also committed to fostering innovative solutions.

NSF has established the Spectrum Innovation Initiative funding program ($17M/yr): this program includes calls such as SWIFT-SAT to provide opportunities for R&D funding for satellite coexistence with ground-based optical astronomy.

NSF Funding opportunity 23-567:
https://new.nsf.gov/funding/opportunities/spectrum-wireless-innovation-enabled-future

More R&D investments are needed worldwide to tackle the challenges.