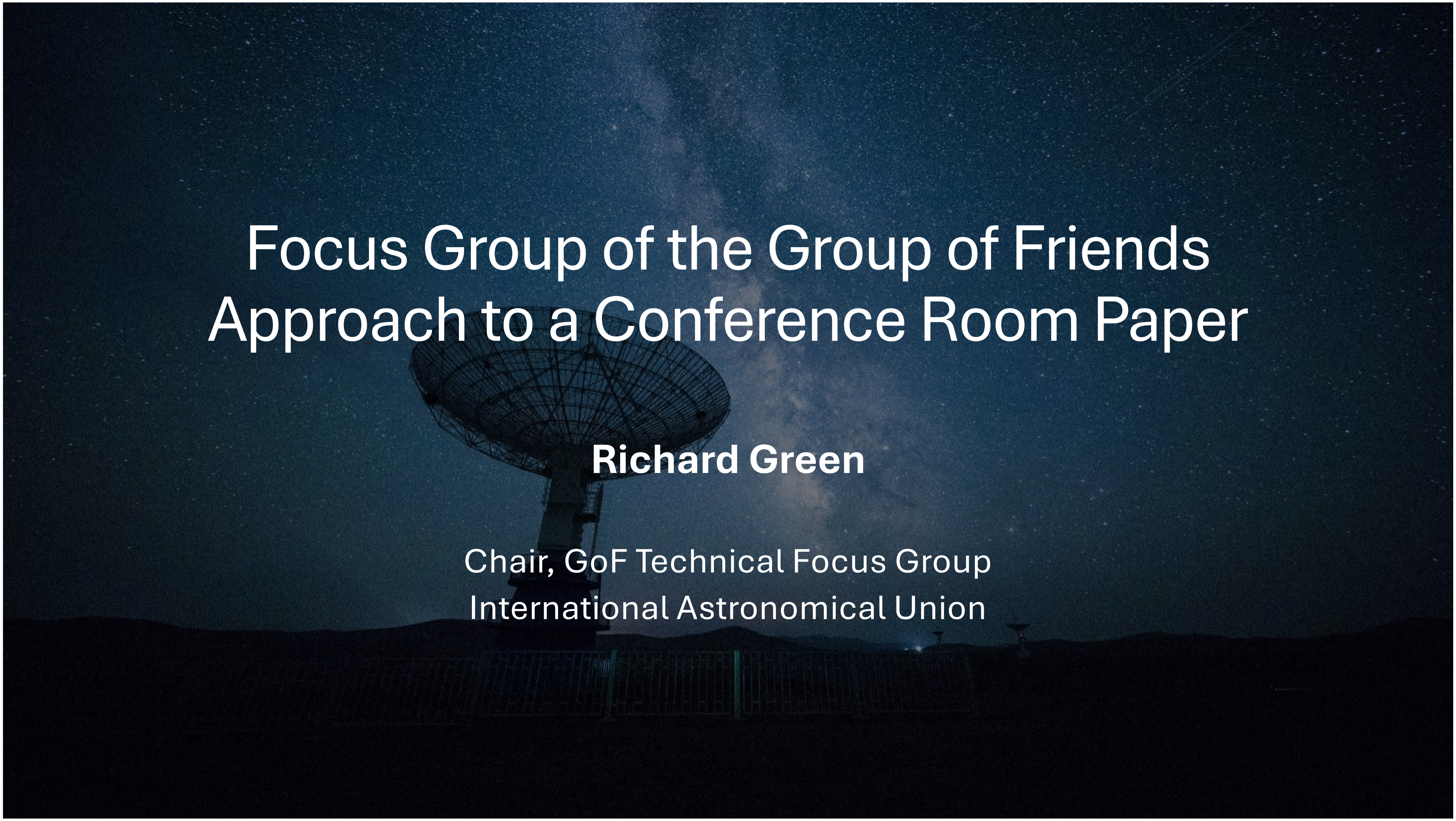

Focus Group of the Group of Friends
Approach to a Conference Room Paper
Richard Green
Chair, GoF Technical Focus Group
International Astronomical Union

Group of Friends of the Dark & Quiet Sky for Science and Society

- The GoF was created under the leadership of Chile and Spain during a special session of IAU Symposium 385 in La Palma (Canary Islands) on October 6, 2023.
- It now includes 22 Member States and ten Permanent Observers of UN COPUOS.
- It was instrumental in creating a five-year agenda item for the COPUOS Scientific and Technical Subcommittee (STSC): "Dark and Quiet Skies, astronomy and large constellations: addressing emerging issues and challenges", starting in February 2025.

Goals of the GoF

- Raise awareness of the impacts of satellite constellations on observational astronomy (good progress)
- Influence Member States to support research and collaboration in the near term.
- Develop a set of guidelines that could be widely adopted by Member States in their licensing and regulatory practices to mitigate impact. (in progress)
- Ensure that the issue is considered and included in broader UN activities, such as LTS 2.5 or UNISPACE IV.

Goals of the GoF Technical Focus Group

- Provide a structured connection for technical (and policy!) experts from the national delegations and observer organizations
- Create awareness of the latest advances in measurement, assessment of scientific progress, technical mitigations, and policy development.
- Advance development of technical guidelines for mitigation and scientific assessment of impact.
- Structure that information into a draft Conference Room Paper for the GoF Steering Committee to adapt and submit as a position of record to the STSC and the COPUOS plenary.

This Year's CRP Plan

- Chair of the Focus Group: Richard Green (IAU)
- Co-Chair: Enrique Allona (Eutelsat)
- Report Section Leads:
  - Optical/IR Astronomy Impacts: R. Green
  - Optical Brightness measurement & mitigation: Robert Massey (Royal Astronomical Society)
  - Operational mitigations: E. Allona
  - Radio astronomy update: Gyula Józsa (MPIfR – Bonn)
  - Best practices endorsement: Thomas Schildknecht (U. Bern); David Lowe / Prakash Puchooa (UKSA)

What's New – Rubin Observatory Workshop

- Held August, 2025, under NSF sponsorship
- Early data to validate modeling predictions
- The largest impact on science is not from the lost sky survey area (caused by masked trails), but from the systematic errors introduced by unmasked trails at the limit of detection.
- Apparent flickering from reflection from irregular surfaces creates a challenge in data analysis.
- The exponentially increasing number of particles of space debris with decreasing size produces single glints and flares that cannot be easily distinguished from celestial phenomena.
- Tumbling faint objects can produce a quasi-periodic line of faint flashes, requiring sophisticated analysis to identify and remove.

What’s New – UKSA Report on Brightness Mitigation

1. Brightness measurement and mitigation should be treated as an operational requirement for responsible activity, and brightness prediction should be a requirement for launch licences.

2. Models for satellite brightness should include an explicit error budget, including factors such as surface reflectivity, attitude, BRDF.

3. Simulations need to take into account glints (brief flashes of light) and specular reflections off smooth surfaces that appear brighter than diffuse reflections.

4. Any brightness prediction tool used for compliance should cover 3D spacecraft geometry and surface optical properties, and orbit and attitude. The software should give the predicted apparent mean and peak (glint) brightness seen from chosen ground locations and times, and provide a formal uncertainty estimate.

What's New – UKSA Report on Brightness Mitigation

5. We recommend that a validation process for predicted brightness be put in place, particularly if minimising brightness is a condition for issuing a licence.

6. Much of the data on coatings and the surface of satellites is proprietary, so understanding their efficacy could be part of the role of trusted third-party agencies.

7. There is a clear need for a civilian-accessible, standardized BRDF reference library for space-facing materials and common appendage geometries, one public and another with proprietary data on coatings and surfaces that can be supplied to trusted agencies.

8. While the brightness per satellite is crucial, equally important is the probability of interference per unit time per unit area of sky from a whole constellation, and the glint probability per unit time.

What's New – UKSA Report on Positional Accuracy

To meet the needs of the Dark & Quiet Skies community, predicted satellite positions must evolve from collision-avoidance-grade data to astronomy-grade ephemerides, characterized by:

- Sub-arcsecond positional accuracy and <30-second timing precision for major constellations;
- Update frequencies approaching hourly or better for active satellites;
- Inclusion of attitude and brightness-relevant parameters;
- Reliable, standardized, and accessible data repositories under international stewardship.

Operational Considerations

- Attitude and array orientation control to minimize reflections during all mission phases;
- Use of steerable solar arrays to reduce reflected light by minimizing exposed surfaces;
- Shortened orbit-raising and de-orbit durations with brightness-aware profiles;
- Boresight avoidance and coordinated frequency management to protect radio astronomy;
- Minimized transmissions during non-operational phases;
- Cross-constellation coordination to ensure consistent mitigation practices.

Operational Considerations

- For the Rubin Observatory in particular and a program concentrating on observations in the dark time after the end of twilight, lower orbits in the range of 350 km had lower impacts in terms of the number of streaks per image by up to 40% compared to those at 550 km.
- Smaller telescopes at higher latitudes and programs dependent on observations near the horizon in twilight could find a different impact.

Radio Astronomy Update

- Aggregate Effects
  - All satellites above the horizon are detectable by radio telescopes
  - The protections of terrestrial radio-quiet zones and remote locations no longer apply to satellites
  - Observations are made in a much broader range of frequencies than those protected by radio regulation, and are becoming more difficult with time
- Direct to Device
  - Commercial goal is to eliminate need for ground station
  - Lower frequencies for cell phones – more difficult out-of-band control
  - Much larger orbiting antennae with higher power required – more sunlight reflection and radio telescope detectability

Radio Astronomy Update

- Unintended Electromagnetic Radiation (UEMR)
  - Low frequencies emitted by operational electronics (not radio transmitters)
  - Well detected in ground-based telescopes and not yet mitigated in newer designs
  - Reluctance by ITU to regulate, because not planned radio transmission with allocated frequency
  - Critical issue for D&QS protection – recommend that administrations support the development of a framework to assess and mitigate the phenomenon of UEMR, and to define the roles of COPUOS, ITU-R, and standardisation institutions.

Policy Update

- French Space Operations Act – 7th magnitude limit
- Proposed EU Space Act – 7th magnitude limit
- US Federal Communication Commission – Coordination Agreement with NSF
- Recommend that the LTS 2.5 Working Group will interface with the Group of Friends, to ensure findings and recommendations are periodically reported and considered.

Basic Request to Member States

- Increasing the accuracy of predictions of position and optical brightness.
- Taking steps to reduce optical brightness.
- Understanding the impact.
- Research support for new technologies and approaches.
- Promoting collaboration and consultation, including with commercial or non-governmental satellite operators and manufacturers.