VIRTUAL TOWN HALL
Industry and Technology Hub

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

March 1, 2023
TOWN HALL AGENDA

1600 – 1605  Welcome and Introductions
   • Tim Stevenson, Co-Chair of I&T Hub/SKAO & Chris Hofer, Co-Chair of I&T Hub/Amazon Kuiper

1605-1615  Overview and Mission of IAU Centre
   • Dr. Piero Benvenuti, Director of IAU Centre & Professor Emeritus, University of Padova)

1615-1625  Satellite Hub Update
   • Dr. Siegfried Eggl, Co-Chair of SatHub and University of Illinois

1625-1640  I&T Hub’s Goals and Workplan
   • Chris Hofer, Co-Chair

1640-1655  Satellite Industry Presentations on Mitigation Developments
   • Dr. David Goldstein, SpaceX Director of Special Programs
   • Dr. Maurizio Vanotti, OneWeb Vice President, New Markets

1655 - 1700  Closing Remarks & Next Steps - Chris Hofer and Tim Stevenson
OVERVIEW:

IAU Centre for the Preservation of the Dark & Quiet Sky from Satellite Constellation Interference

Dr. Piero Benvenuti, Director
UPDATE:

Satellite Hub of the IAU Centre

Dr. Siegfried Eggl, Co-Chair
GOALS & WORKPLAN:
Industry & Technology Hub of the IAU Centre

Chris Hofer, Co-Chair
Industry and Technology Hub

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

Chris Hofer, Amazon Kuiper & Tim Stevenson, SKAO
Co-Chairs
Virtual Town Hall, March 1, 2023
The Optical/Infrared Astronomy Concern with Satellite Constellations

- Constellation projects of multiple satellites in Low-Earth Orbit (< 2,000 km altitude) are proliferating now, with tens of thousands of satellites proposed in regulatory filings from around the world.
- Demand drivers for satellite constellations are critical services of high economic and social value, including broadband connectivity, earth imaging and weather observation.
- Satellites in sunlight may be more visible when operating over regions otherwise in darkness, making them more detectable to the naked eye and to astronomical observation - however, the lower satellites operate, the less time they are in the sun.
- Various mitigations have been tested and deployed since 2020, with promising results:
  - Darkening key spacecraft surfaces or shielding them from the sun’s direct reflection;
  - Altering spacecraft orientation at key operational phases;
  - Sharing specific satellite location data to allow observatories to plan with satellite passes in mind.
- While results to date have not yet reached the proposed visibility target, this field of technology development is still relatively new and innovation efforts continue.
The “Industry Hub” aims to engage the technical insights of both satellite stakeholders and astronomers to build the tools and resources to develop solutions and 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 for their particular project

- 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 & Technology Hub Objective: Connecting satellite & astronomy communities to find & deploy solutions

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<th>OUTREACH</th>
<th>RESOURCES</th>
<th>EXCHANGE</th>
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<td>• Enlist satellite constellation operators, manufacturers, other stakeholders to participate and collaborate in finding and deploying mitigations</td>
<td>• Develop references to inform and to educate on astronomy’s concerns, and share recommendations and best practices to date</td>
<td>• Foster development and adoption of mitigation techniques; encourage sharing their efficacy and lessons learned, and encourage innovation in new approaches and tools (materials, test labs, simulation software, etc.)</td>
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Notional I&T Hub onboarding process for New Satellite Constellation Operators

1. **Enlist**: Invite priority constellation operator to participate in Industry Hub

2. **Educate** - Recommend Essential Reading, Astronomy Overview

3. **Support** - Pair with Astronomer Overview, Invite to Technical Advisors

4. **Assess** - Evaluate Constellation, Spacecraft using predictive software

5. **Options** - Discuss mitigations/best practices from Case Studies

6. **Options** – identify any shared solutions from other industry players

7. **Secure operator commitment to apply mitigations**

8. **Identify Labs, predictive software for ground-based test of prototype**

9. **For first satellite deployment, coordinate with observation network for measurements**

10. **With first deployments, test out satellite location data publication**

11. **Confirm visibility; ongoing observations**

12. **Industry Hub includes constellation among good stewards of space**
OUTREACH: Major LEO satellite constellation operators committed to participating; contacted all key constellation proponents. An additional 30+ Volunteers from industry, academic/research institutes offered their time.

MULTIPLIERS: Engaging leading satellite trade groups & manufacturers to amplify outreach

PLANNING: Workplan developed to shape the Hub and its activities. Feedback from early bilateral discussions are helping to scope the tools and resources companies need.

PROCESS: Finalizing an on-boarding plan to prepare, support and encourage Hub participants to assess their plans and consider mitigations.

TOOLS: Building reference library, essential reading lists, consolidated best practices and recommendations, and shared technical resources to educate and inform. Early work on marketplace for solutions - several operators already developing products, brightness models available to all.
• INFORM yourself through our “Essential Reading List”
• REVIEW the latest recommendations & best practices

• ENGAGE with the I&T Hub and other operators in discussions about mitigation techniques and available resources & tools

• ASSESS the visibility of your deployed satellites by tapping into the Consolidated Observation Network or predictive software

• JOIN other satellite operators in discussing how to develop practical and promote adoption

• HELP to develop predictive tools for use before deployment, like:
  • **Ground laboratories** to test satellite prototypes using Bi-directional Reflectance Distribution Function (BRDF) measurements
  • **Modelling software** for satellite manufacturers to assess visibility in the design/test stage
  • Further basic research on reflectivity of spacecraft materials and designs

• ENCOURAGE other satellite stakeholders to become aware and participate in the Industry & Technology Hub
Thank you for your kind attention!

IAU CPS Industry & Technology Hub
Contact: industry-tech@cps.iau.org
More Info: https://cps.iau.org/
SATELLITE INDUSTRY MITIGATION UPDATES:

David Goldstein
SpaceX
SATELLITE REFLECTION MITIGATIONS
Current Starlink Deployment

3,700+ satellites launched into low Earth orbit
1,000,000+ customers on all seven continents

200 Mbps (improving to 1 Gbps) speeds far exceed other satellite systems and are competitive with some terrestrial systems

Gen-2 system critical to fulfilling customer orders and scaling Starlink service approved in 2022, as part of license SpaceX completed a coordination agreement with the US National Science Foundation

Making a Difference!

- Starlink is making a huge positive impact for hundreds of thousands of people around the world, while also advancing space sustainability and safety.
- Supporting connectivity to numerous communities, Tribes, school districts, health centers, scientific stations, enterprise customers, and small businesses.
- Focus initially on remote, rural communities with un/underserved households.
- Helping to close the digital divide in the U.S. and around the world.
Mechanism for Satellite Reflections

- Mag 7 target corresponds to a standard white sheet of paper at 550 km altitude...so every single component must be considered.
Mitigations in Three Areas

- **Hardware and satellite design**
  - Shade the reflective surfaces
  - Specular materials can scatter light away from Earth
  - Dielectric Bragg mirror film
  - Dark materials can be used to absorb light
  - Pigmenting solar arrays and black paint
  - Other accommodations
    - Oversize solar arrays so they can off-point to reduce reflections
    - Robust thermal design to accommodate more absorbed heat energy

- **Satellite Operations**
  - Off-pointing solar array during orbit raise
  - Autonomous attitude adjustments as satellite approaches terminator
  - Off-pointing solar array
  - Biasing bus pointing to reduce likelihood of light reflections toward Earth's surface

- **Satellite position predictions**
  - Publish accurate ephemeris predictions that include planned maneuvers and make them publicly available
  - Publish Two Line Elements (TLEs) with planned maneuvers included
Mitigations In Action 1/3
https://twitter.com/i/status/1630394434847227909
Mitigations In Action 3/3

https://twitter.com/i/status/1630394434847227909
Conclusion

• Starlink is making a huge positive impact around the world, while keeping space safe and sustainable

• Through coordination with astronomers and industry-leading standards on space sustainability, SpaceX continues to innovate and implement mitigation solutions

• We welcome collaboration with other operators, and are making in-house products available to other companies
SATELLITE INDUSTRY MITIGATION UPDATES:

Maurizio Vanotti, OneWeb
Space, the future of communications on Earth

- Our network is in its final phase of deployment
- The constellation configuration and operational orbits are fault-tolerant, and rigorously tested to assure quality and reliability prior to launch.
- OneWeb embraces a “Leave No Trace in Space” philosophy in the design and operation of its constellation.
- Innovation is key for the OneWeb to mitigate risks, accelerate development and anchor them in Europe to leverage the strong industrial ecosystem.
Leadership in Responsible Space

ESG defines criteria that socially conscious investors/customers/regulators use to screen potential investments/products/licences.

1. SSA  
Space Situational Awareness
- Constellations should not overlap in altitude.
- Key metrics shall include the reliability for de-orbiting.
- Propulsion should be required for orbits higher than 400 km.
- Risk should be evaluated on a system-wide basis (not per satellite).

2. STM  
Space Traffic Management
- Act responsibly to avoid top-down traffic control imposed on telecom operators.
- Transparent coordination among operators is key.
- Actively engaging with WEF on satellite collision avoidance “Right of Way”.

3. ADR  
Assisted Disposal & Removal
- Satellite should either be ‘designed for demise’ or for targeted re-entry.
- In Orbit Servicing is uncharted territory.
- Foster service diversity in order to avoid monopolistic scenarios.
- Actively working with service providers and ESA.

4. RF Interference  
Radio Astronomy
- Astronomers use a band adjacent to the Ku band that OneWeb uses.
- OW avoids using our Ch. 1 to avoid interfering into the RF band.

5. Brightness  
Optical Astronomy
- Sharing the position of our satellites in the sky.
- Engaged with leading international astronomers.
- Corelation between observations and simulations to positively influence the future design.

6. Carbon Footprint  
Greenhouse Gas (GHG)
- Engage with WEF on Space Sustainability Rating.
- Executed independent assessment of OneWeb’s end-to-end supply chain.
Brightness Prediction & Model Correlation
Brightness Prediction & Model Correlation

6th November 2021

Maximum difference: 0.54

|Difference| mean value: 0.23

|Difference| STD: 0.16
Thank you for your kind attention!

IAU CPS Industry & Technology Hub
Contact: industry-tech@cps.iau.org
More Info: https://cps.iau.org/