Conclusions from the SATCON2 Observations Working Group

Coordination, Training, and Data Sharing

Meredith Rawls, SATCON2 Observations Working Group Chair

on behalf of the SATCON2 Observations Working Group:
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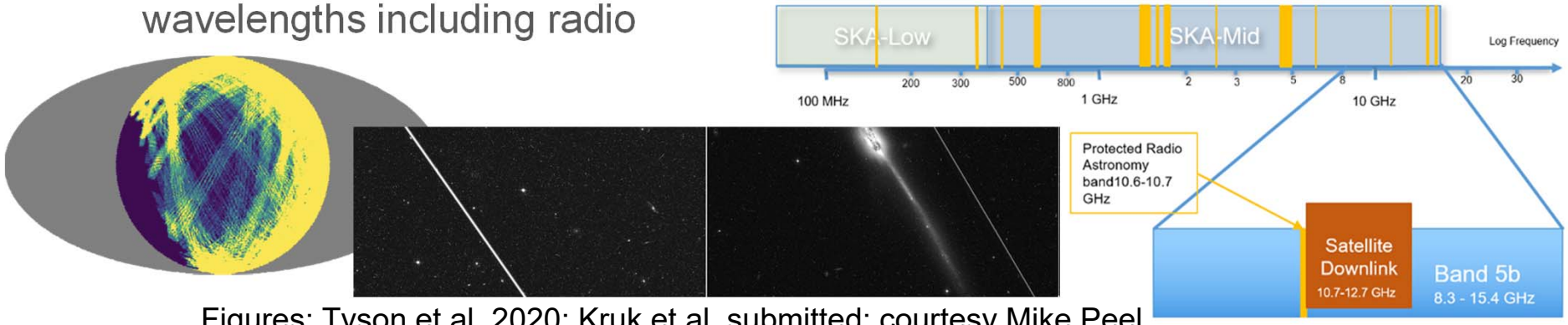
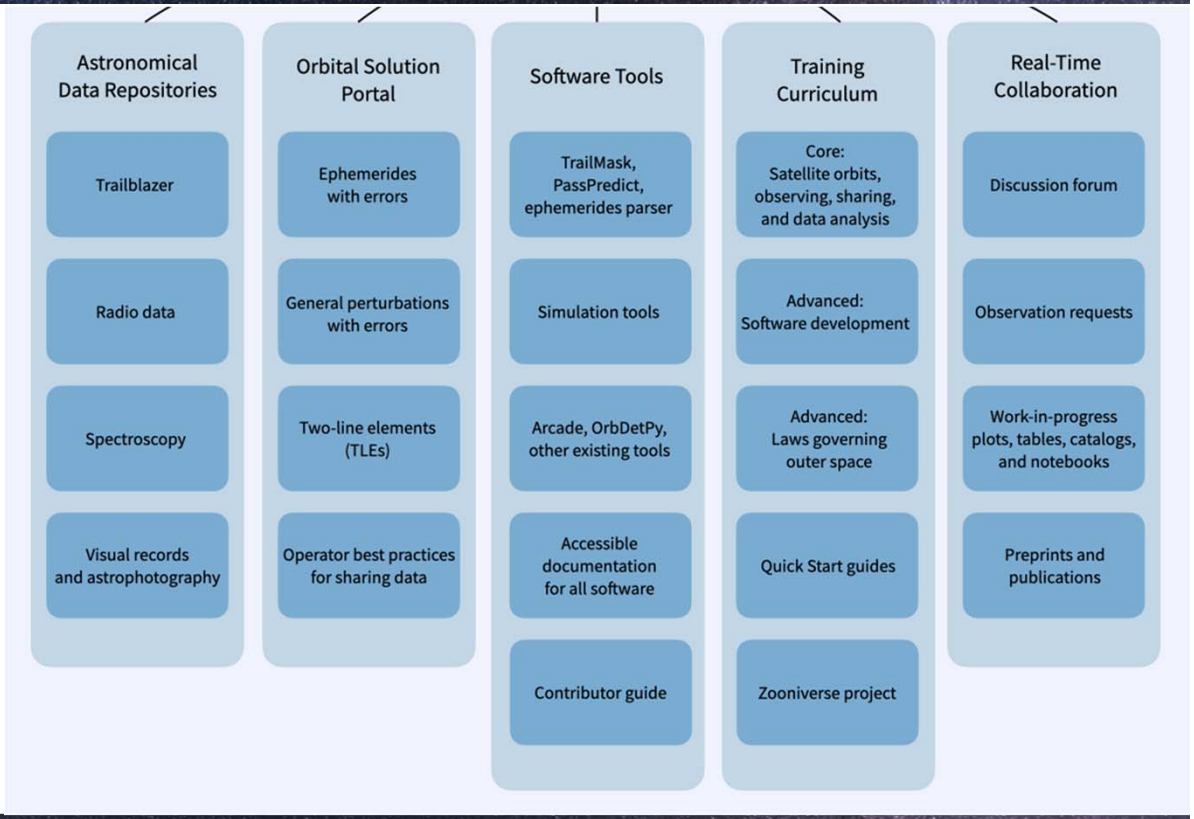
Goal: make a plan to implement SATCON1 Recs 8–10

- Rec 8: Coordinating observations of satellite constellations
- Recs 9 & 10: Requirements for operators sharing data
- WG includes satellite operators, educators, astronomers who use ground- & space-based observations, entrepreneurs, and international experts at many wavelengths including radio



Figures: Tyson et al. 2020; Kruk et al. submitted; courtesy Mike Peel

SatHub: a one-stop shop for training, outreach, and collection & analysis of LEO satellite observations



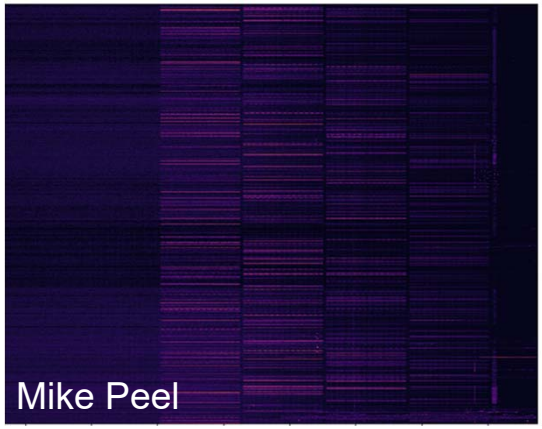
SatHub: a one-stop shop for training, outreach, and collection & analysis of LEO satellite observations

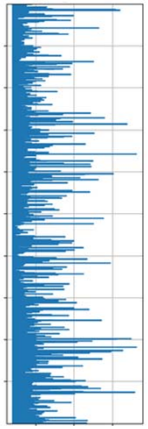
- Coordinated observation-focused hub enabling astronomers, community members, and operators from around the world to work together
- Primary goal: inform and enable timely LEO satellite observing
- Secondary goal: host software, tutorials, ephemerides, images and data
  - Software (see SATCON2 Algorithms WG!) with documentation and tutorials
  - Instructions for specific observer setups, including unaided eye
  - Lesson plans and citizen science projects for educators
  - Connections to queryable affected data products (e.g., Trailblazer)
- Natural home at the future IAU Centre for the Protection of the Dark Sky from Satellite Constellation Interference; funding model TBD

Astronomical data repositories

Publicly available, easily accessible, user-friendly, and documented

- Collection of optical/NIR FITS files with satellite streaks
- Spectra contaminated with reflected solar spectrum from satellites
- Space-based observations from LEO (e.g., Hubble)
- Radio data affected by satellite interference
- DSLR images, visual sightings, and other formats



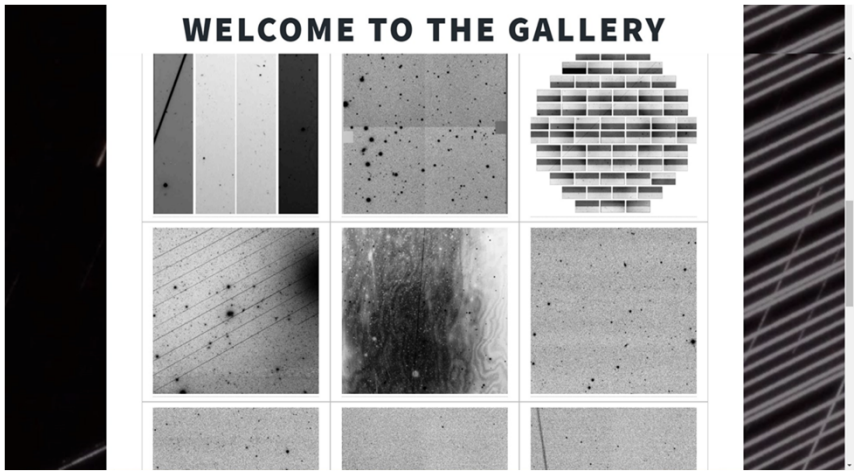


Trailblazer: An open data repository for astronomical data products affected by satellites

- Two main use cases:

1. An astronomer can think, “my otherwise perfectly-good non-proprietary observations have these darn satellites in them, I’ll submit them to Trailblazer real quick so it’s not a total loss”
2. Groups seeking to characterize the extent of the satellite streak problem have ready access to a dataset to quantify impacts to ground-based optical and NIR astronomy

- Led by team at UW’s DiRAC Institute
  - https://github.com/dirac-institute/trailblazer



Coming in early 2022!

Training curriculum for observers worldwide

- A crucial part of SatHub — a global LEO satellite monitoring campaign and piles of shared data and software alone are insufficient
- Outline of a training curriculum for observers of all kinds
  - Core curriculum (intro, observing satellites, reporting observations, image/data analyses)
  - Advanced modules (software development, radio astronomy, laws governing outer space)
  - Quick start recipes (for different observer hardware scenarios)
- Stay tuned for Fatoumata Kebe's talk to learn more!

Standard requirements for present and future LEO satellite operators to aid all night sky observers

1. Publicly provide orbital solutions every 8 hours or immediately following a maneuver, whichever is first, always with error bars
2. Publicly provide any other relevant metadata (beaming strategies, reflectivity, nominal flux densities, BRDF, etc.)
3. Adopt standard formats for both ephemerides-style and general perturbation-style (“TLE”) orbital solutions
4. Financially support the Orbital Solution Portal part of SatHub

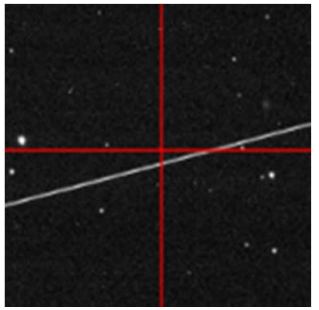
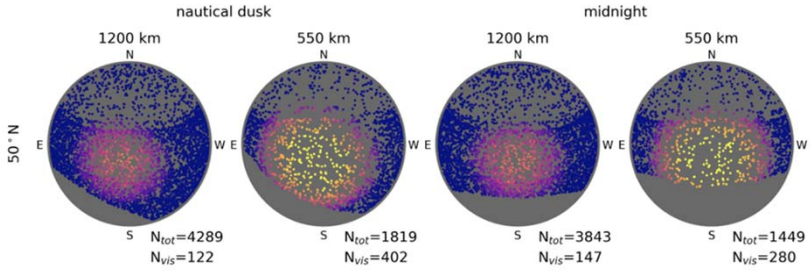
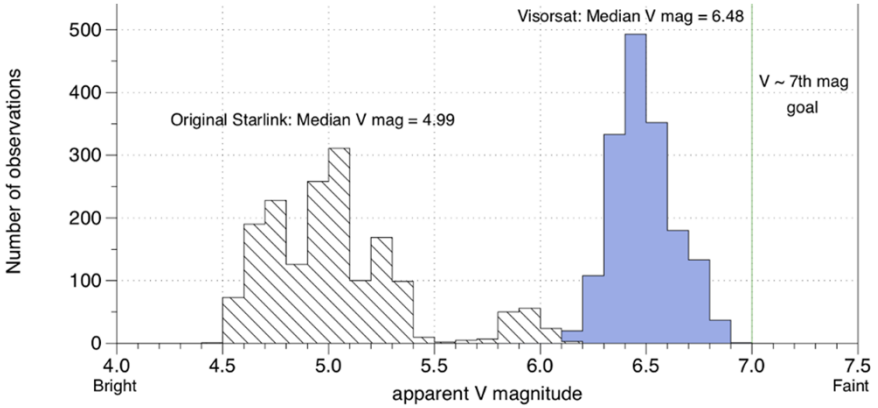


Figure: Jeremy Tregloan-Reed

Fast pace requires observer-operator dialogs

- Key design needs remain low orbits (< 600 km) and darkening (> 7th V mag), but as we study broader impacts, these may evolve
- Many aspects of SatHub will be useful for industry, and we hope these will attract funding from satellite operators





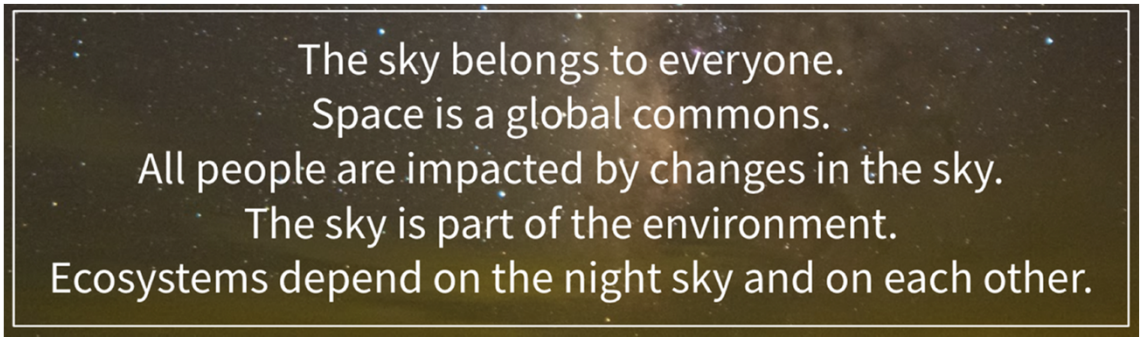
Figures: Lawler et al. 2021, courtesy Pat Seitzer

Impacts on science and observers worldwide

- **Rubin Observatory:** most severely impacted optical/NIR facility; Tyson et al. 2020 recommends satellites be > 7th mag and < 600 km altitude
  - **Weak lensing:** spatially correlated noise from removed trails
  - **Near-Earth asteroids:** fewer discoveries and orbit determinations
  - **Other:** ??? depends on the particulars of your program and the changing satellite population
- **Higher latitude observatories:** (e.g., Canada) see Lawler et al. 2021
  - TL;DR: Lower satellite altitudes are not a panacea
- **Spectroscopy:** solar spectrum contamination you might not notice without simultaneous imaging to rule out coincident satellite passes
- **Radio astronomy:** … where to begin … ! come back Thursday

Impacts on science and observers worldwide

- We are all observers
- We won't know what we don't discover



J. Lowenthal, A. Venkatesan, & SATCON2 Community Engagement Working Group

We have a plan for a coordinated observation hub, and we need dedicated resources urgently to make it a reality

- SatHub ought to land at the future IAU Centre
- **Astronomical data repositories**, a **training curriculum**, and an **orbital solution portal** are key SatHub aspects outlined by the SATCON2 OBS WG
- **Software tools** and **real-time collaboration** are the remaining two aspects
- Each of these must be fully public, open, and accessible for astronomers, satellite operators, policymakers, and anyone anywhere to work together
- This is a “light pollution moment of truth” for ground-based astronomy
- Our choices today set precedents for how LEO is used for decades to come