Collaborative Research: SWIFT-SAT: Coexistence of Remote Astronomical Instruments Susceptible to Interference with Large Comm Sat Constellations

Constance E. Walker[1] , Siegfried Eggl[2], Samuel Cornwall[2], Michelle Dadighat[1], Nayan Jangid[2], Michael Peel[3], Meredith L. Rawls[4], Mark A. Skinner[5] and J. Anthony Tyson[6]

1 NSF NOIRLab, AZ, USA
2 University of Illinois Urbana-Champaign, IL, USA
3 Imperial College London, UK
4 University of Washington & DiRAC, WA, USA
5 The Aerospace Corporation, USA
6 University of California Davis, CA, USA

On behalf of SatHub at the IAU Centre for the Protection of the Dark and Quiet Sky (CPS)
Email: sathub@cps.iau.org

More satellites during LSST will require a range of mitigations

With 100,000+ satellites likely to launch in the near future, trails in astronomical images will become frequent enough to require some form of mitigation in Rubin's Legacy Survey of Space and Time (LSST). While pixel loss is currently manageable [SMTN-018] due to large field of view (FOV), **science impacts are not yet fully understood** (Fig. 1).

Key mitigation strategies include: satellite design and deployment in dialog with operators [e.g., 3, 6], avoiding bright satellites [2], excluding known satellites from alerts [DMTN-199], rejecting transients from coadds [DMTN-080], detecting and masking streaks and glints in difference images, and addressing systematic errors from faint signals that fall below the detection threshold. To learn more, visit **ls.st/satcon**.

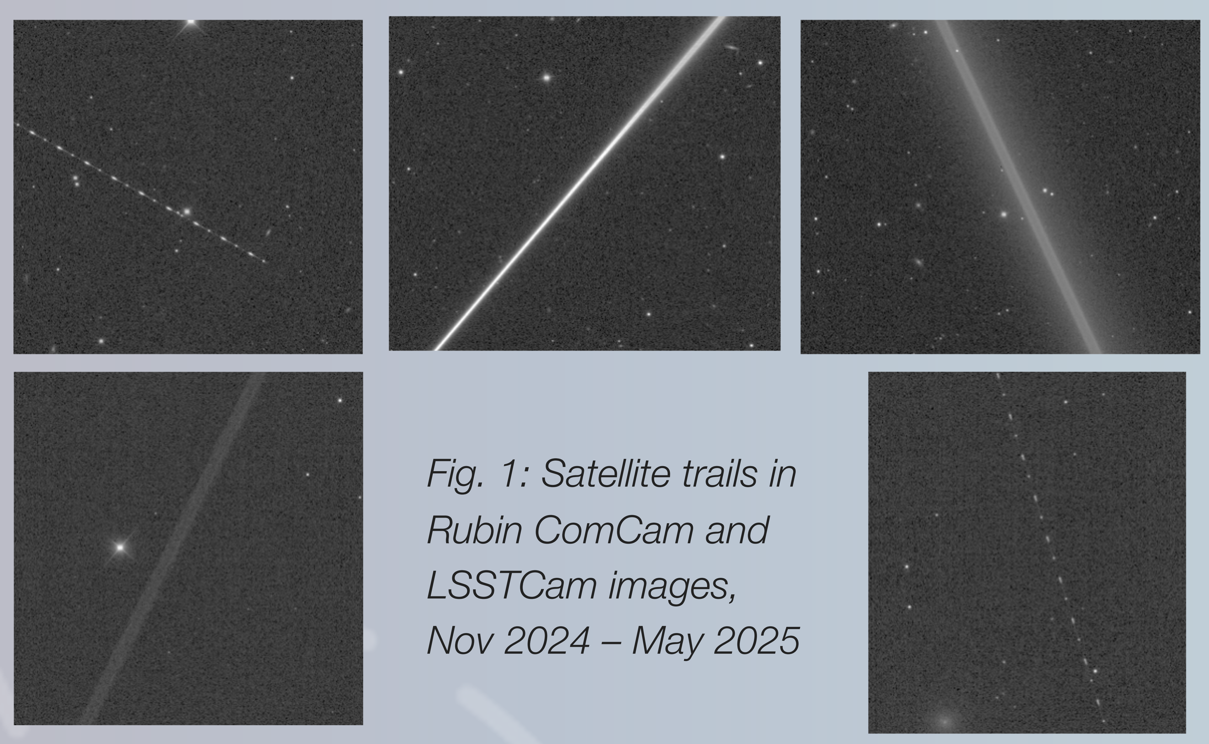

Fig. 1: Satellite trails in Rubin ComCam and LSSTCam images, Nov 2024 – May 2025

New Strategies: Lower orbits and satellite avoidance

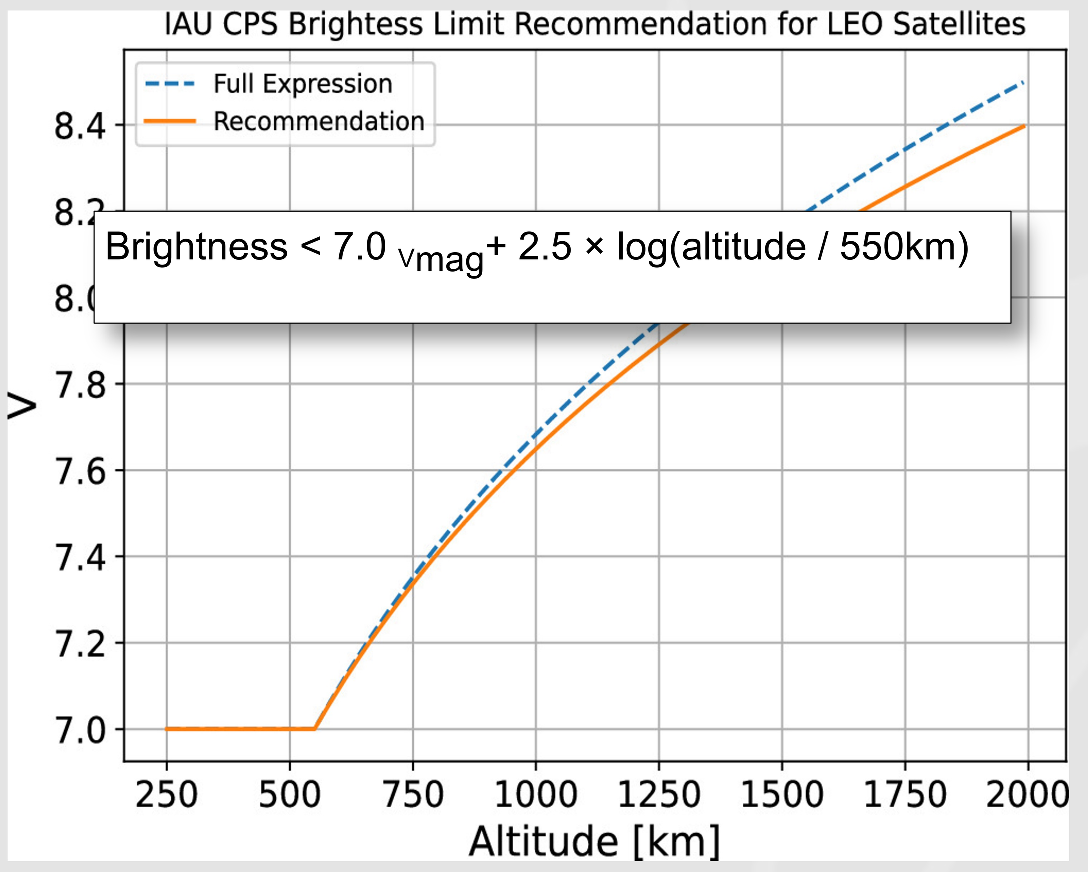

Fig. 2: IAU CPS Brightness Limit Recommendation [1]

The IAU CPS optical brightness recommendation for satellites in LEO [1] takes into account higher streak surface brightness for slower-moving, higher-altitude satellites (Fig. 2). Many constellation satellites significantly exceed this limit [4, 5].

LSST can avoid some bright satellites in principle with the feature-based scheduler, but doing so would effectively decrease observing time and thus coadded depth [2].

Recent findings [3] demonstrate that **lowering satellite orbits**, while increasing maximum satellite brightness, may reduce the overall impact of Starlink V2 satellites on LSST (Fig. 3).

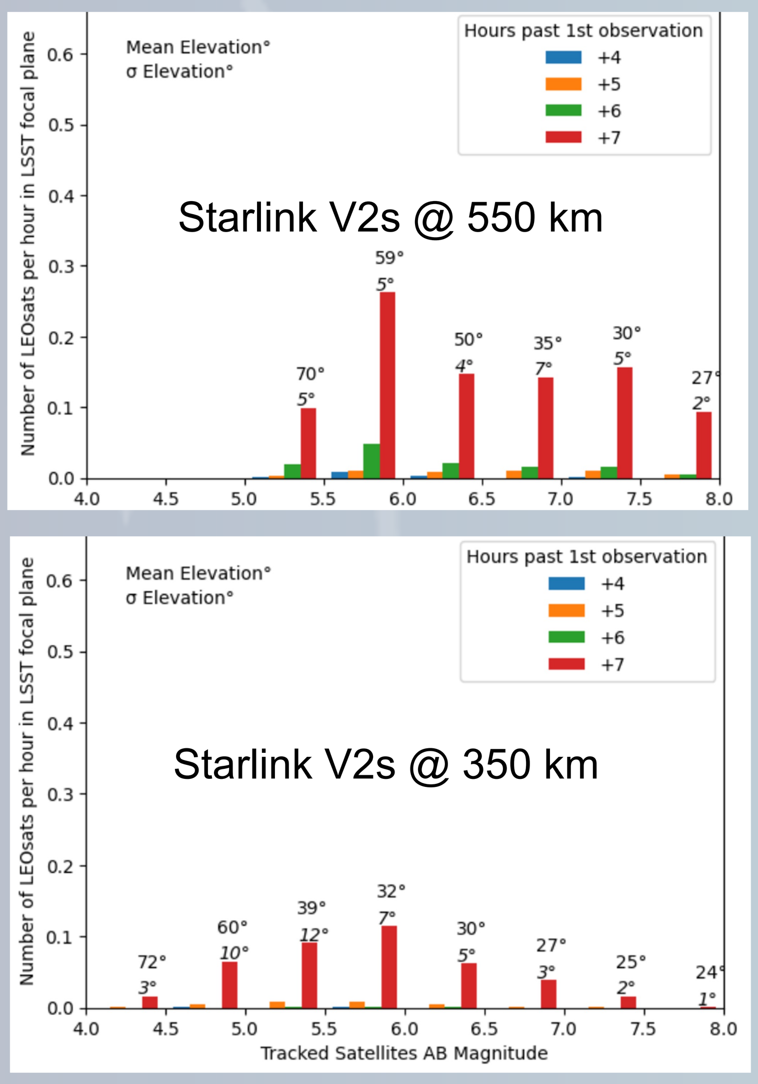

Fig. 3: Impact of Lower Satellite Orbits [3]

SatChecker: enabling satellite avoidance

SatChecker uses public TLEs (two-line element sets) to **predict satellite on-sky positions at a given time and from any location** (Fig 4). The service also provides information on whether or not a satellite is "illuminated". Known BRDF models and higher precision ephemerides will be integrated to predict brightness in the near future.

Documentation, including APIs and examples: **satchecker.readthedocs.io**

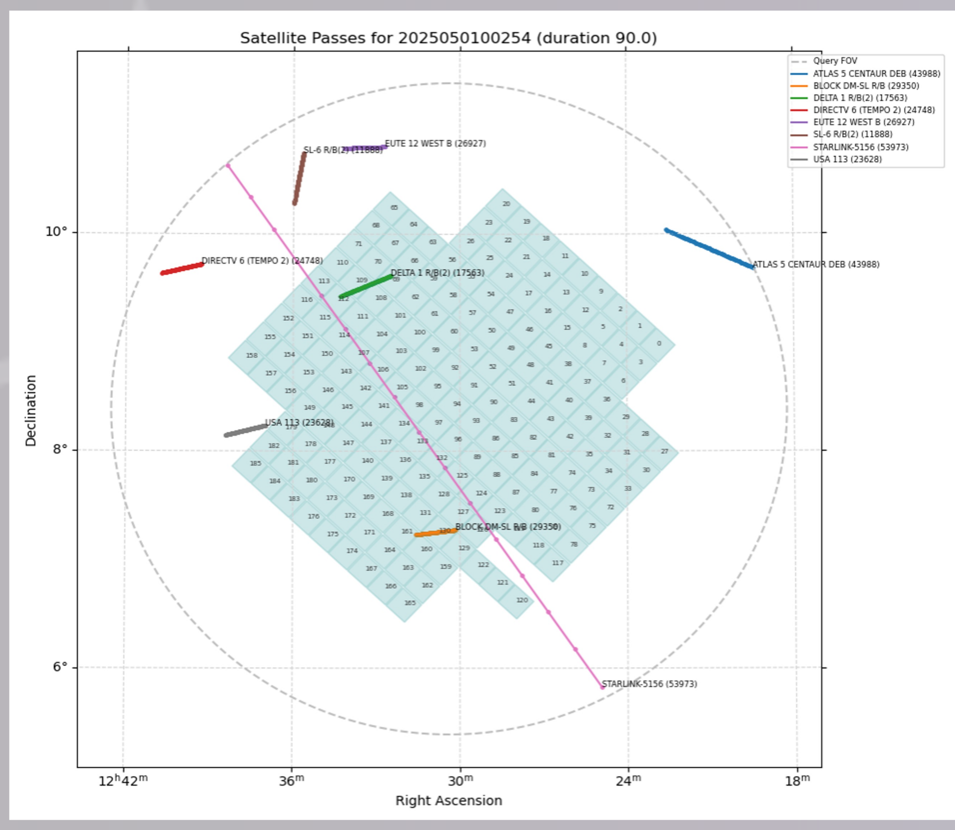

Fig. 4: SatChecker predictions of satellite passes within +/- 30s of a May 1, 2025 LSSTCam visit

SCORE

To assist with the observational validation in brightness as well as position prediction, SCORE, the Satellite Constellation Observation Repository [7], was developed for researchers to contribute, store and access satellite observations. SCORE offers **free and easy access** to satellite brightness data and provides convenient visualization tools (Fig 5).

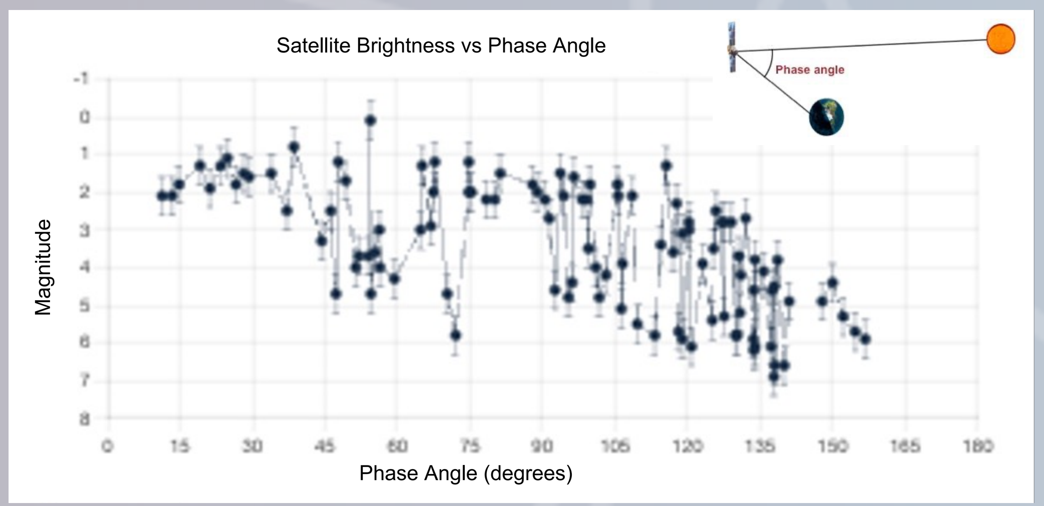

Fig. 5: SCORE visualization of brightness vs phase angle for SPACEMOBILE-002

References

[1] A. C. Boley et al. 2025, RNAAS, 9(3), p.60
[2] J. A. Hu et al. 2022, ApJL, 941(L15), p.6
[3] P. Kandula et al. 2025, arXiv:2506.19092
[4] A. Mallama & R. E. Cole 2025, arXiv:2507.00107
[5] R. E. Cole et al. 2025, arXiv:2505.05820
[6] NSF and Amazon's Project Kuiper establish satellite coordination agreement, 2025 June
[7] S. Eggl et al. 2024, IAU General Assembly, p.1206, https://score.cps.iau.org/

SatChecker

SCORE

Acknowledgments

NJ, SE, MS, TT and CW acknowledge support from the National Science Foundation (NSF) through Award Numbers 2332735 & 2332736. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the NSF. TT acknowledges support from NSF/AURA/LSST grant N56981CC, NSF grant AST-2205095, and DOE grant DE-SC0009999 to UC Davis.