

Satellite Constellations and RADIO ASTRONOMY



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March 5, 2020 – IUCAF 5th School



2020:
A decade with
new opportunities



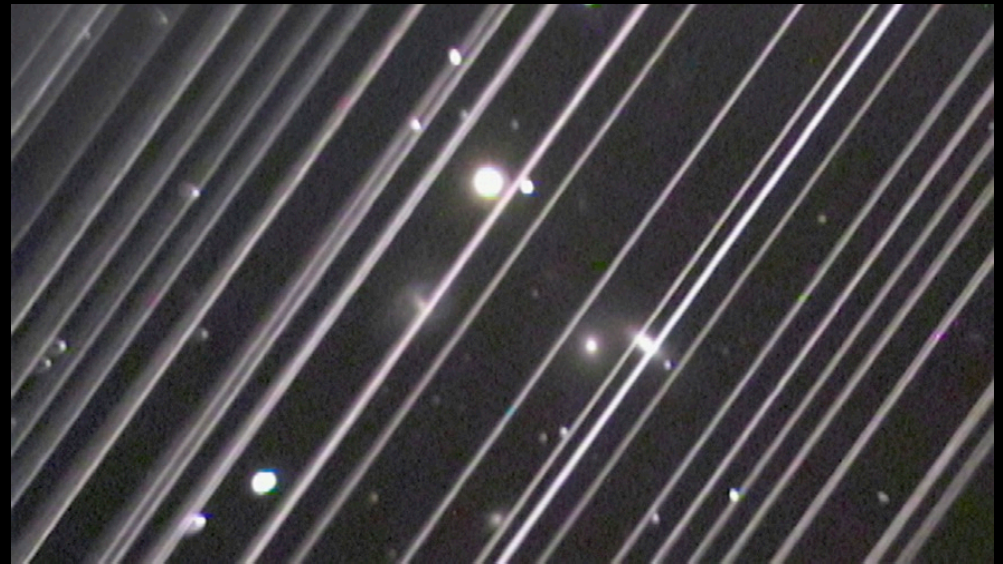
Credit: LSST



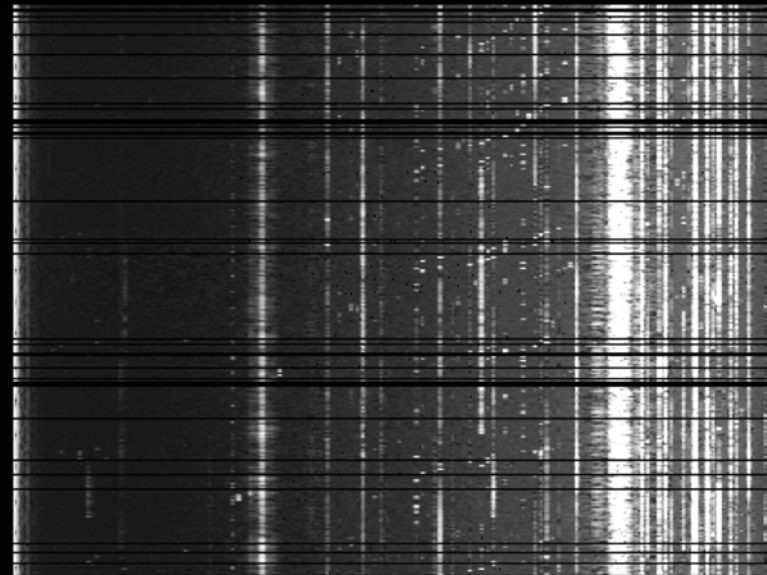
Credit: almaobservatory.org



2020:
A decade with
new opportunities
and
new challenges



optical interference



radio interference

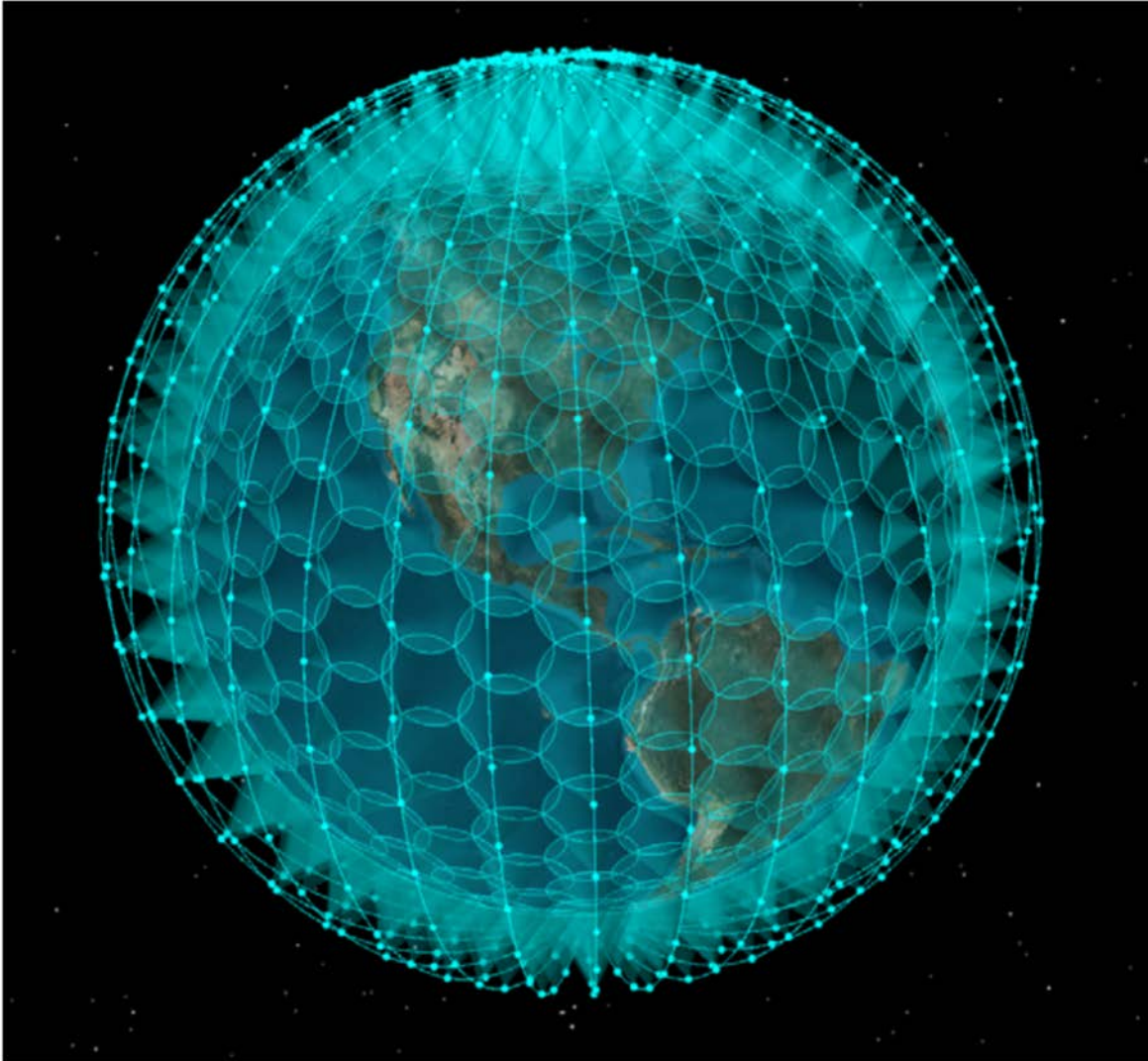
- **What is coming?** Constellations of thousands of NGSO satellites (10-50+ GHz transmitters) such that from any location you would always “see” at least one and up to 3 or 4 satellites or more!



Credit: University of Southampton



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ONEWEB NGSO
satellite constellation
coverage; from SE40
ECC 271 report (Fig. 1)



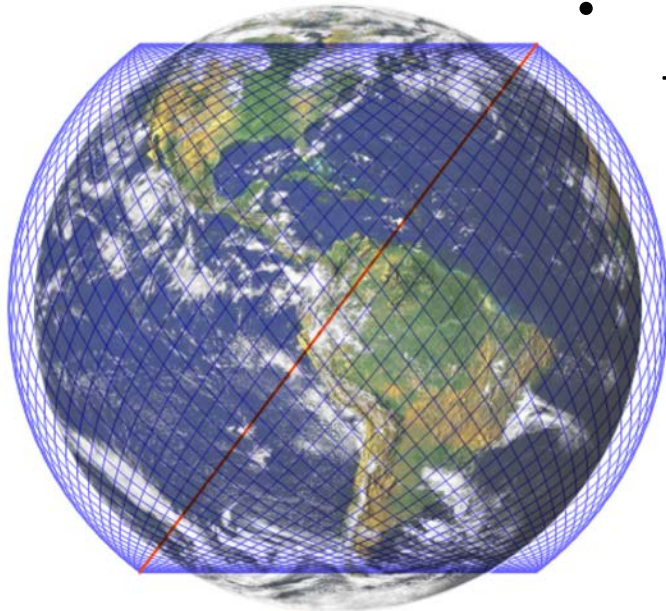


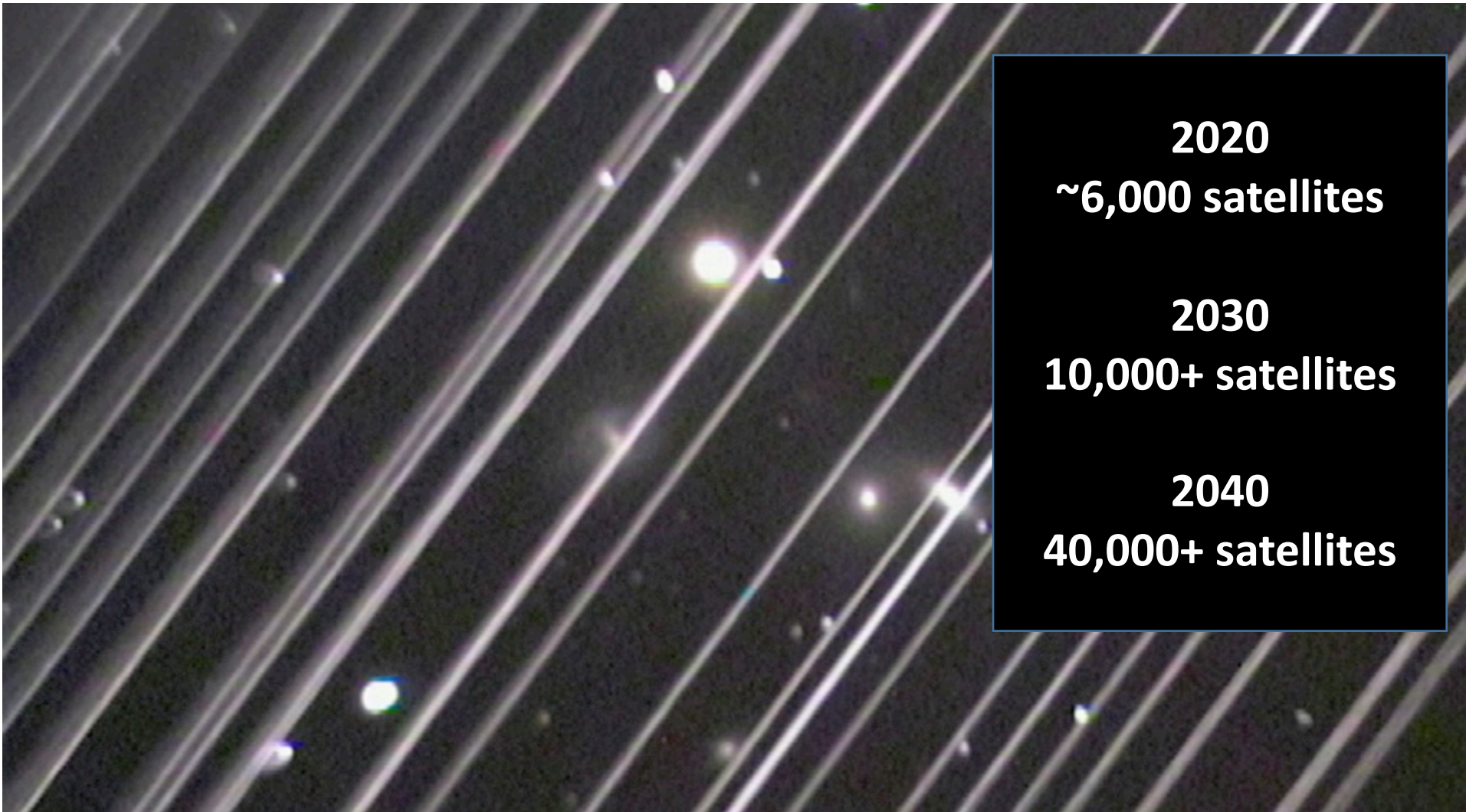
Changes in Satellite Constellations

- Numbers of satellites is increasing;
-factor of 10 over the next 20 years
- Type of orbit is changing;
-GSO -> NGSO constellations in LEO; 500 – 1200 km
-Closer, brighter
- Radio frequencies utilized is increasing;
-problem for radio astronomy

Starlink Initial Phase

1,584 satellites into 72 orbital planes
of 22 satellites each





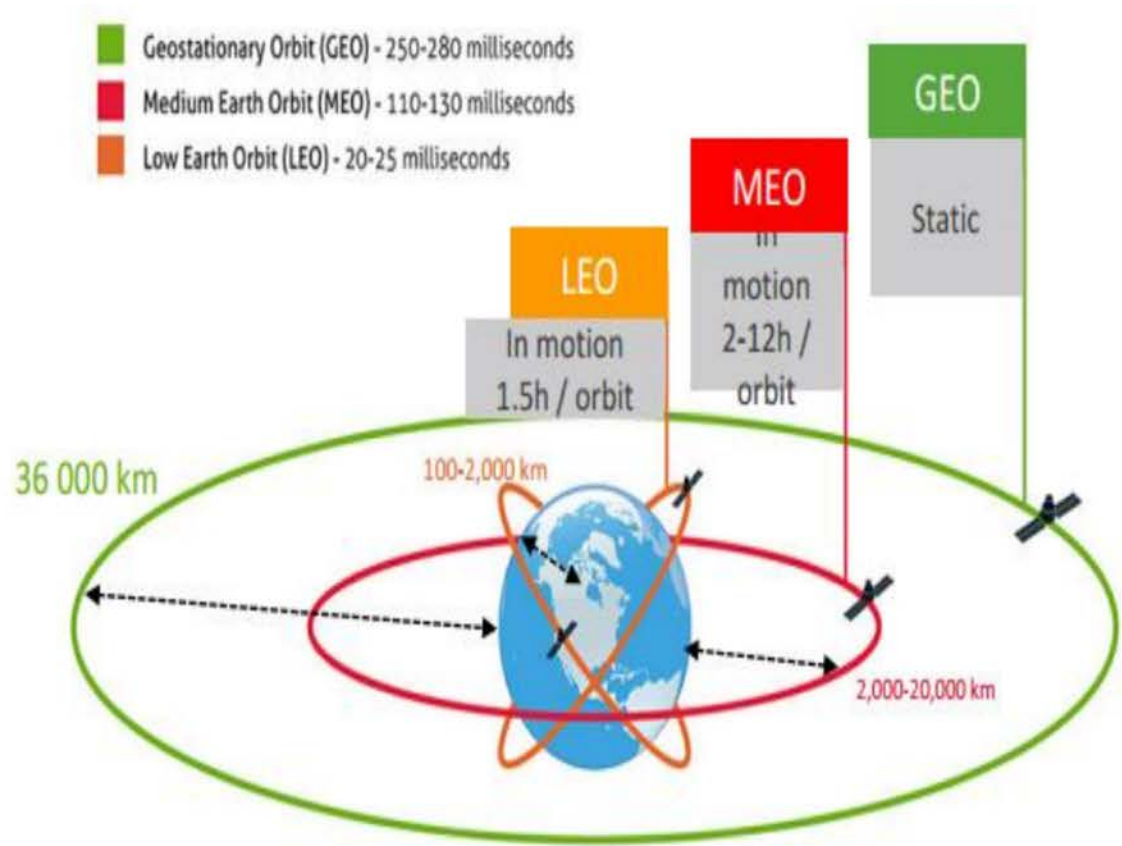
Optical image of NGC 5353/4 galaxy group (25 May 2019)

Image Credit: Victoria Girgis / Lowell Observatory

<https://www.iau.org/public/images/detail/ann19035a/>

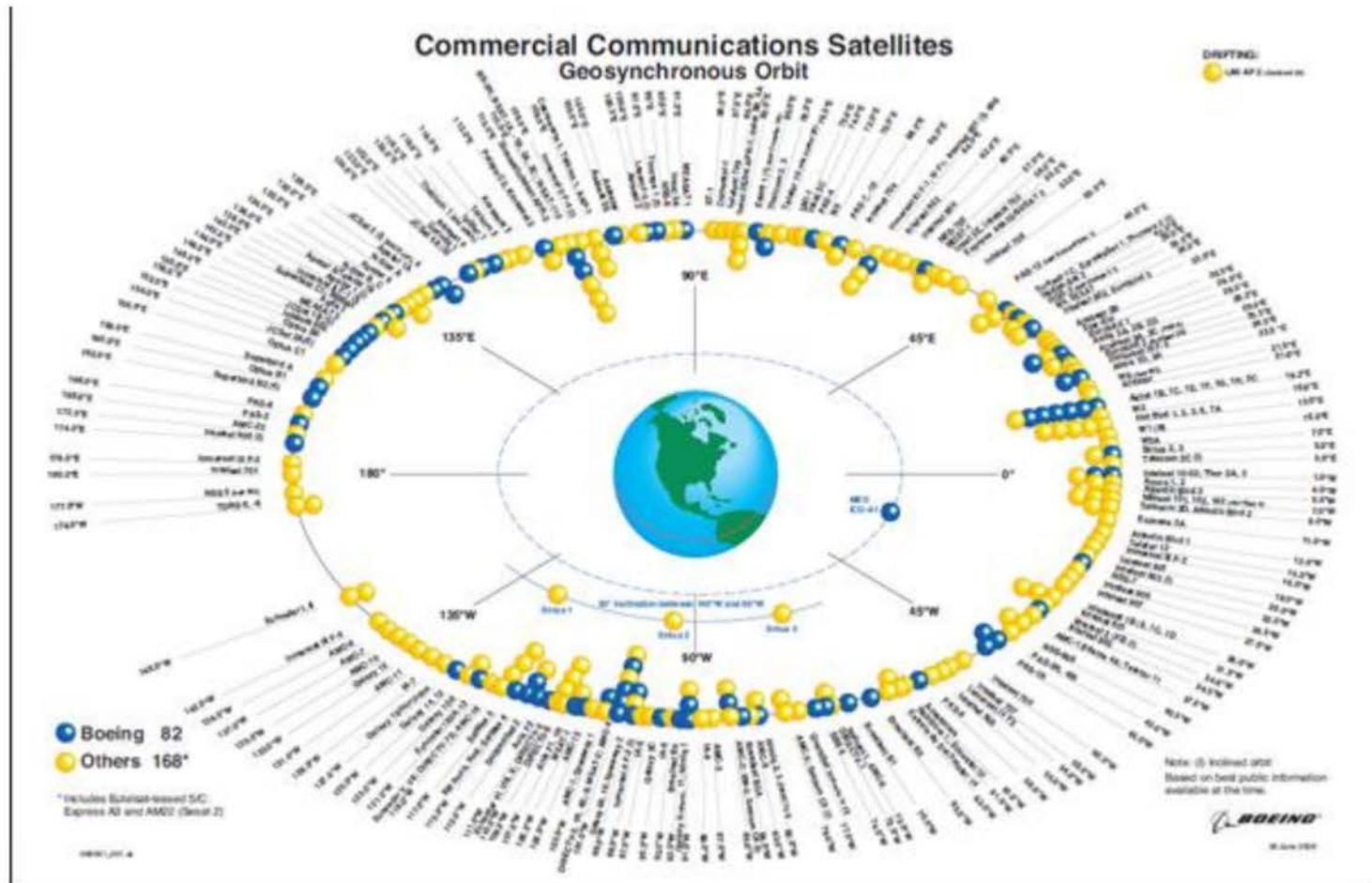


Satellite orbits

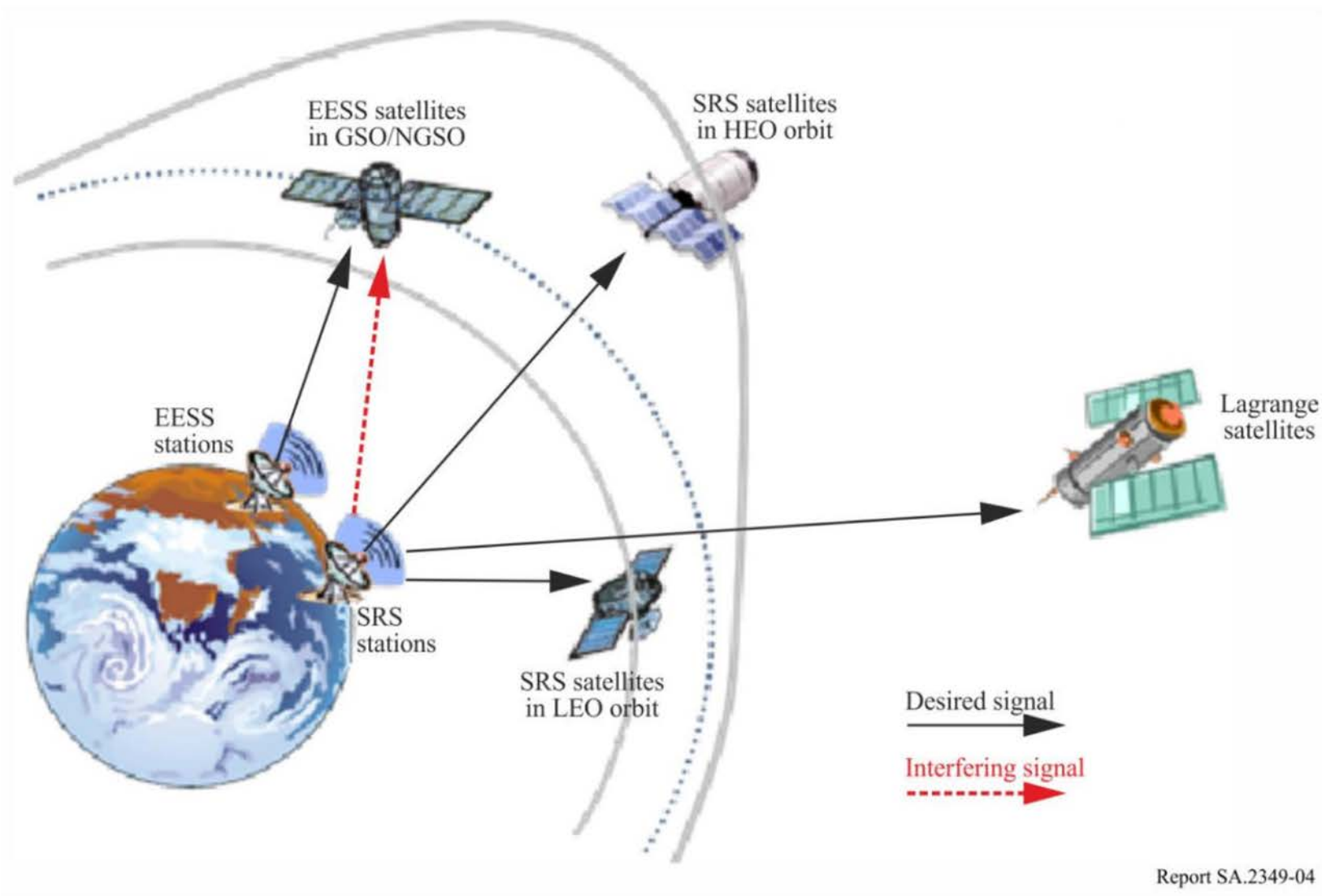


Note: Not drawn to scale

GSO Orbital slots



https://futurenetworks.ieee.org/images/files/pdf/Webinars/5G_satellite_ieee_webinar.pdf



Report SA.2349-04

Figure from ITU-R Report SA.2349-04

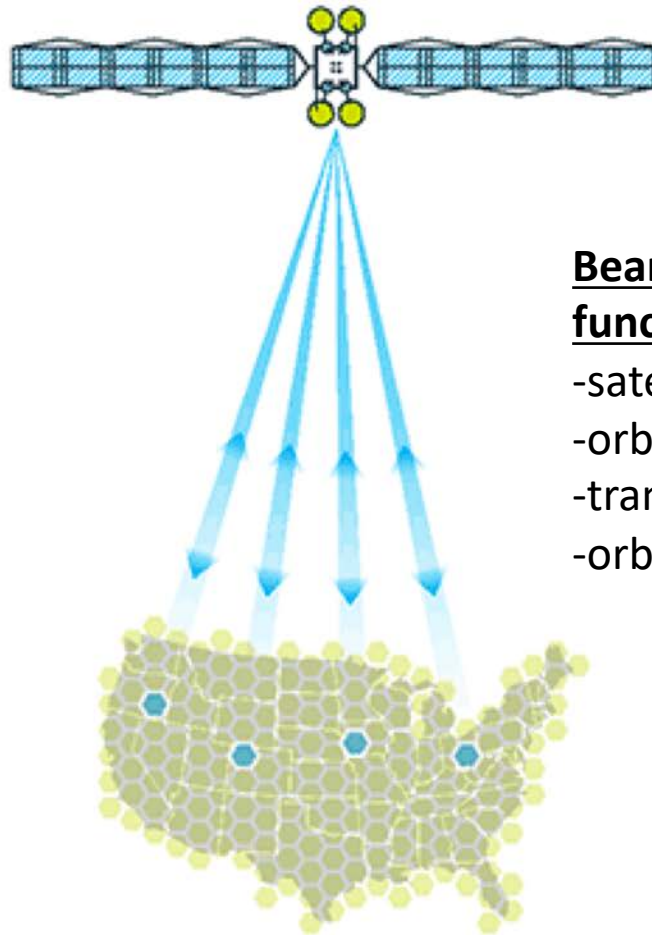
Some Characteristics of NGSO Systems to Consider:

- type of orbit, LEO, MEO, HEO etc.;
- orbit altitude;
- orbit inclination (to the equatorial plane);
- number of planes;
- number of satellites per plane;
- satellite size;
- satellite shape and design;
- aggregate impact of multiple NGS systems;
- reflectivity of material;
- whether satellite can re-orient real-time;
- earth station location and minimum elevation.

Modified from SE40 ECC report 271



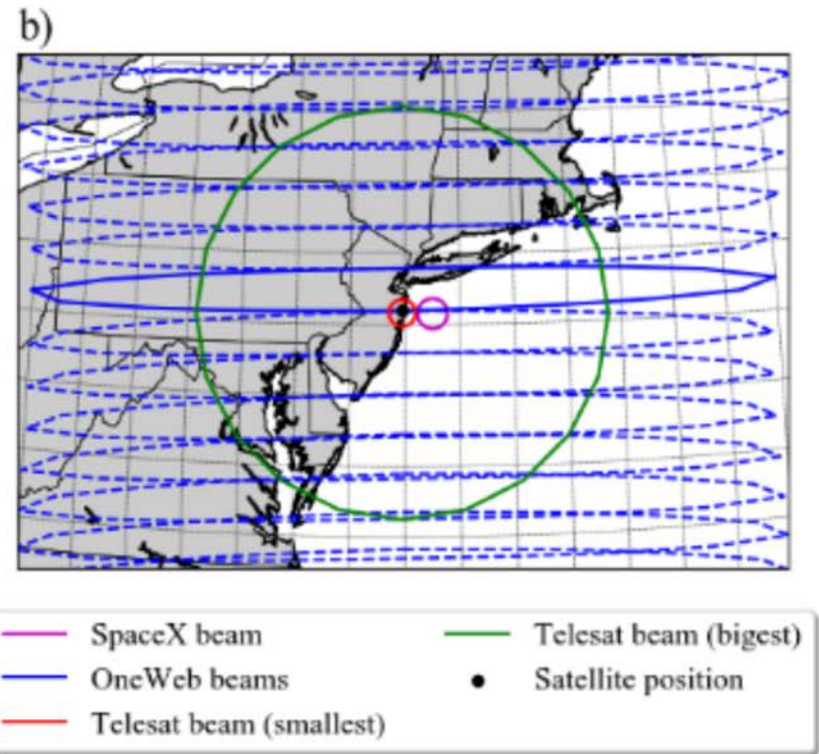
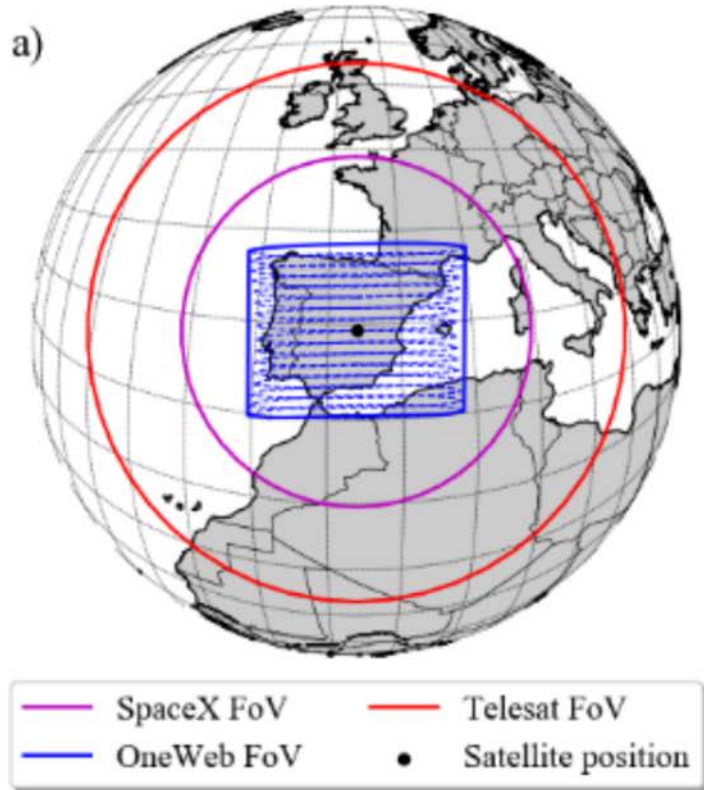
Single beam,
one-way video broadcast



Spot beams for
satellite internet

Beam footprint is a function of:

- satellite design
- orbit altitude
- transmitting frequency
- orbital parameters



- Figures from presentation by Portillo et al.; see <http://www.mit.edu/~portillo/files/Comparison-LEO-IAC-2018-slides.pdf>



Methodology for calculating data loss matters...

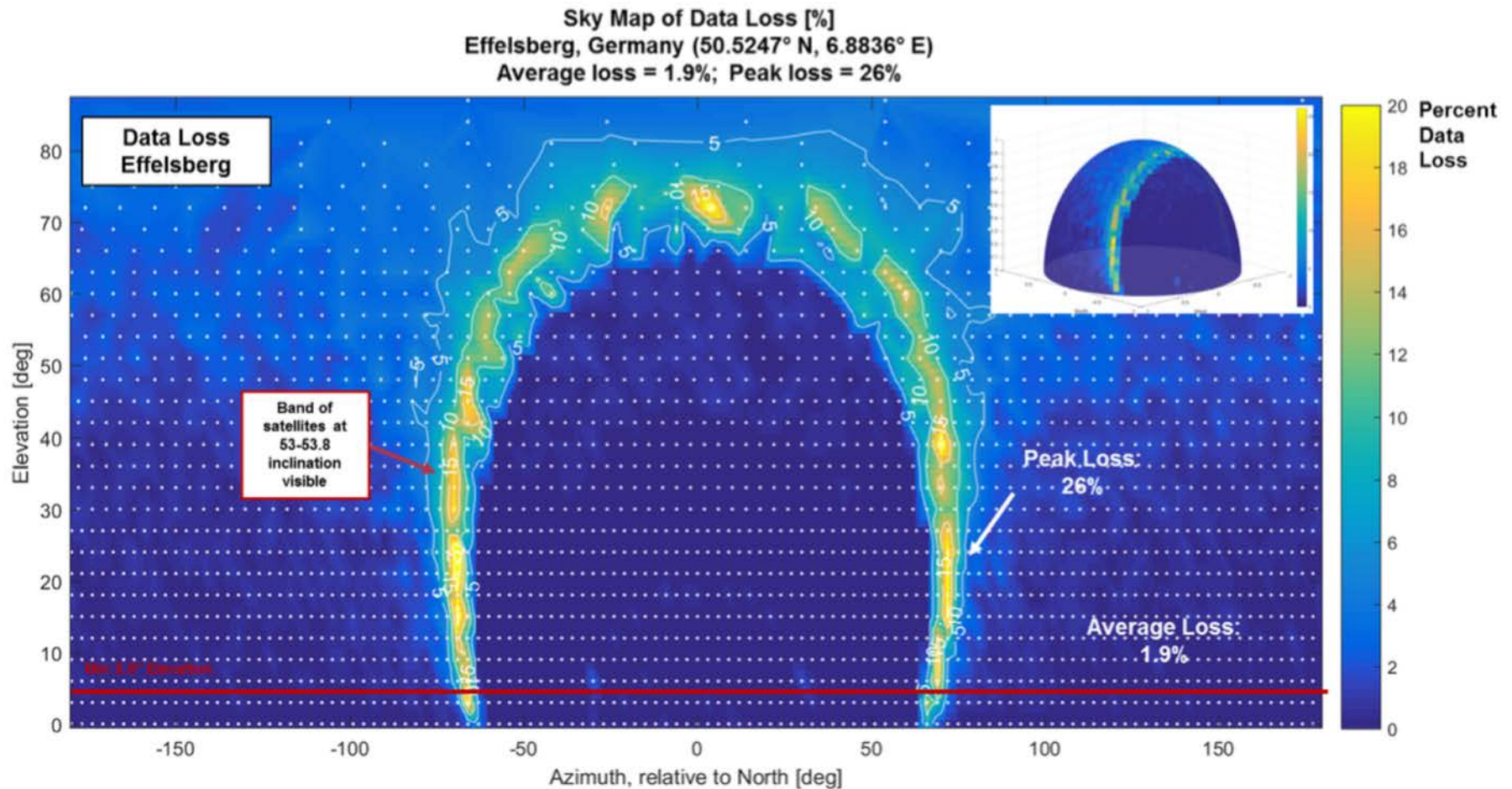


Figure 64: Effelsberg – Sky Map of Percent Data Loss



Geographic Isolation of RAS sites: less helpful for RFI from satellites

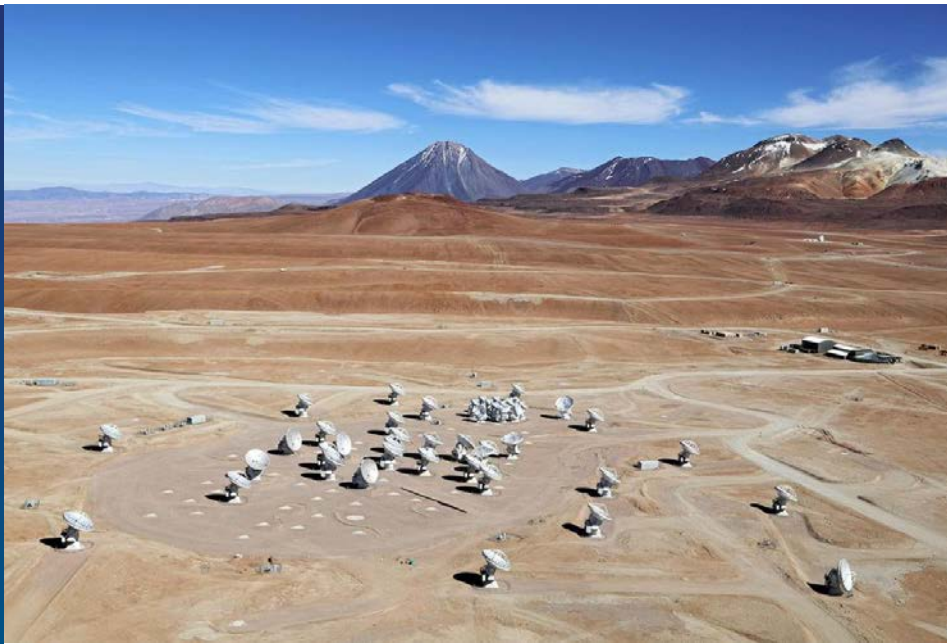


Image credit: almaobservatory.org



Summary

- Number of satellites anticipated to increase by ten-fold
- Satellites have different characteristics (NGSO, LEO) than we are accustomed to in our data; rapidly changing deployment scenarios (e.g. change to FCC filings)
- Initial studies indicate a serious data loss for radio astronomy sites, including in the internationally protected bands



Questions and Comments

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