Radio Astronomy in a New Era of Satellite Radiocommunication

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SCIENTIFIC COMMITTEE ON FREQUENCY ALLOCATIONS FOR RADIO ASTRONOMY AND SPACE SCIENCE

IUCAF

NRAO

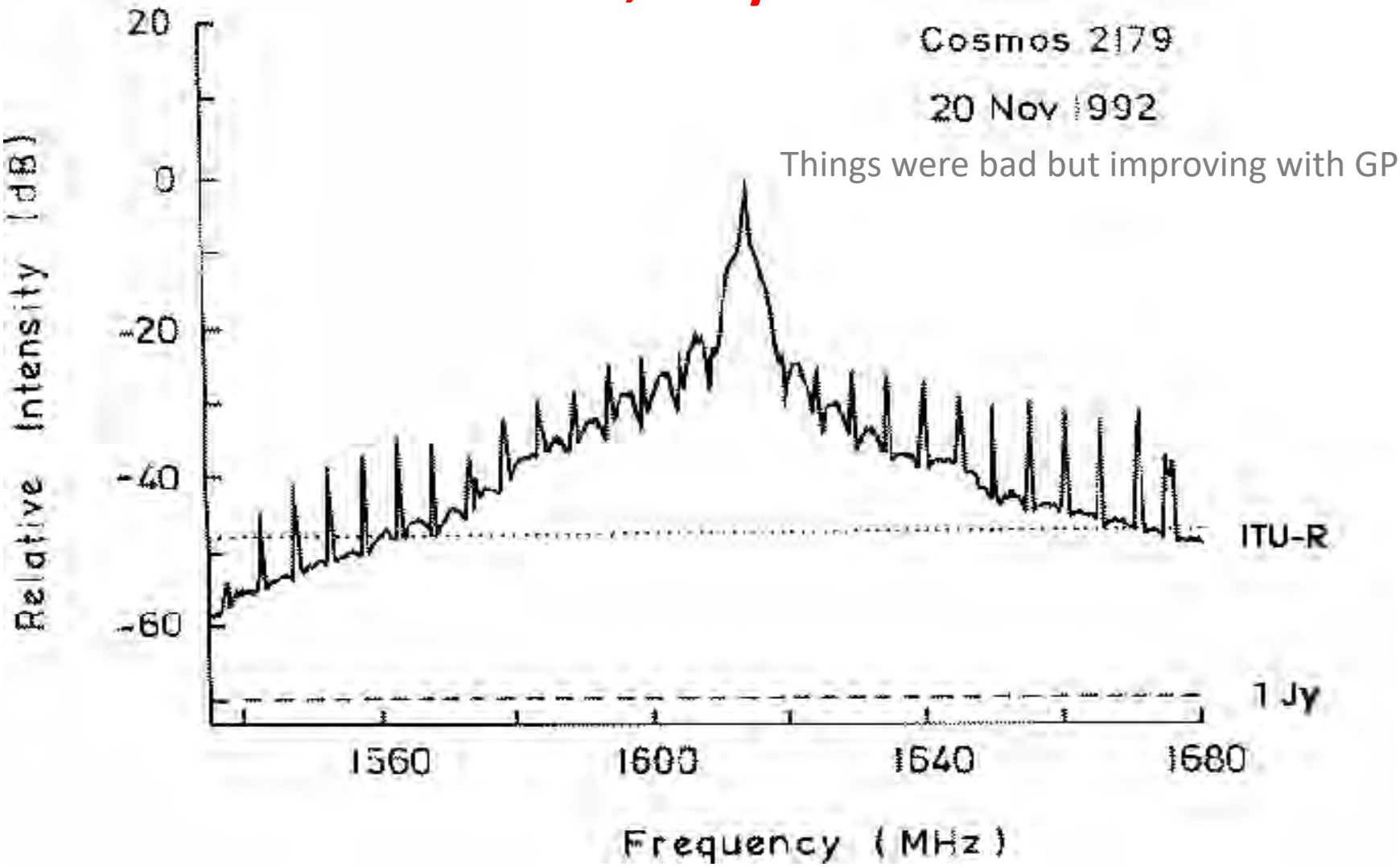
Radio spectrum historically thinly-sliced & strongly-regulated

"Spectrum Management"

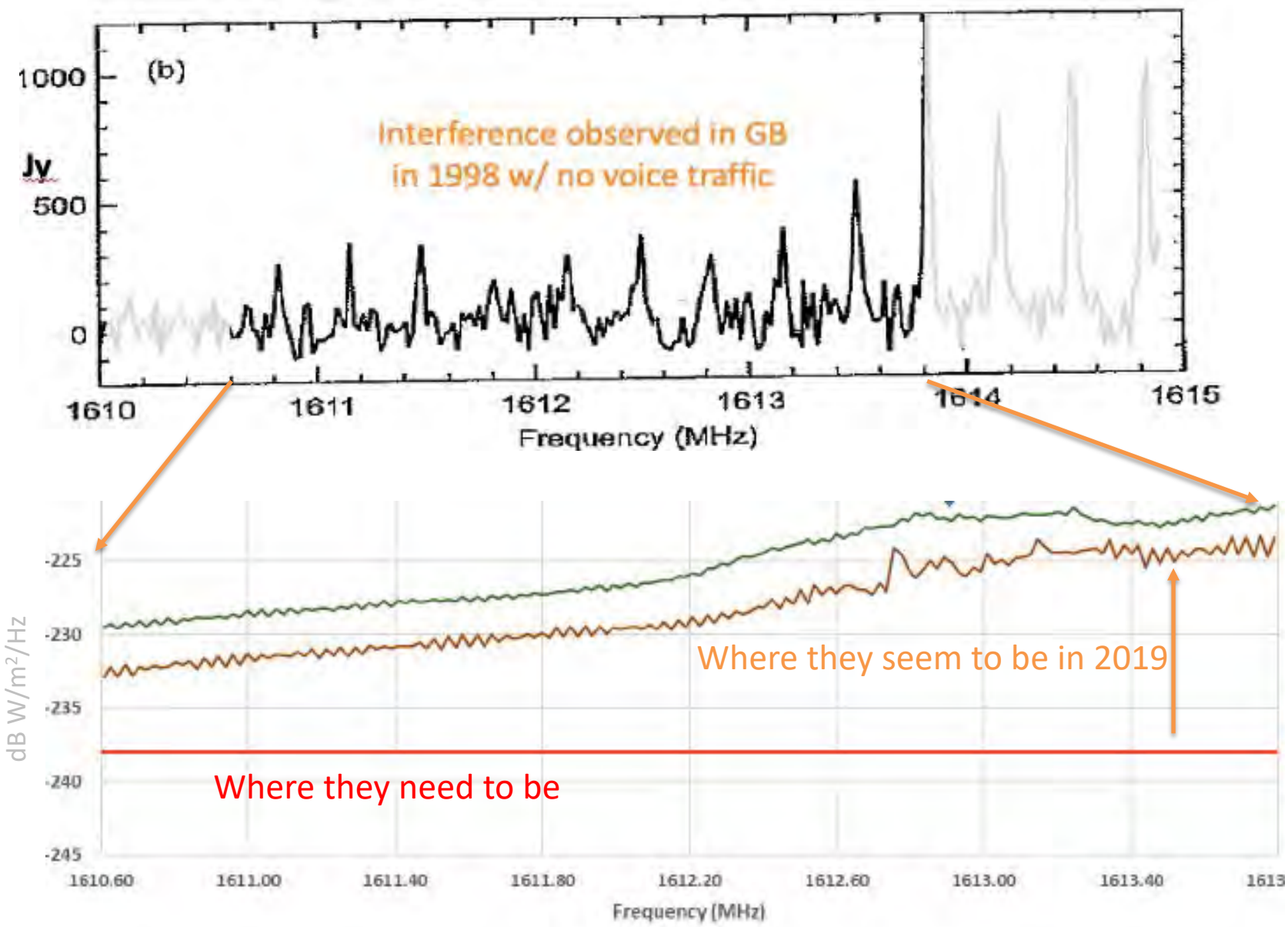
- 1957, 1958, 1960
  - NRAO & National Radio Quiet Zone created in US
  - IUCAF created to gain protection for 21cm HI line at at WARC-59 in Geneva (1400-1427 MHz)
    - 1st passive band, it & others now used for climate study
- 1978+1984, 1998, 2004
  - Ah-ha moments for radio astronomy when GPS, GLONASS, Iridium, and CloudSat radar launched

RNSS

GLONASS 1992, 8 yrs after 1st launch



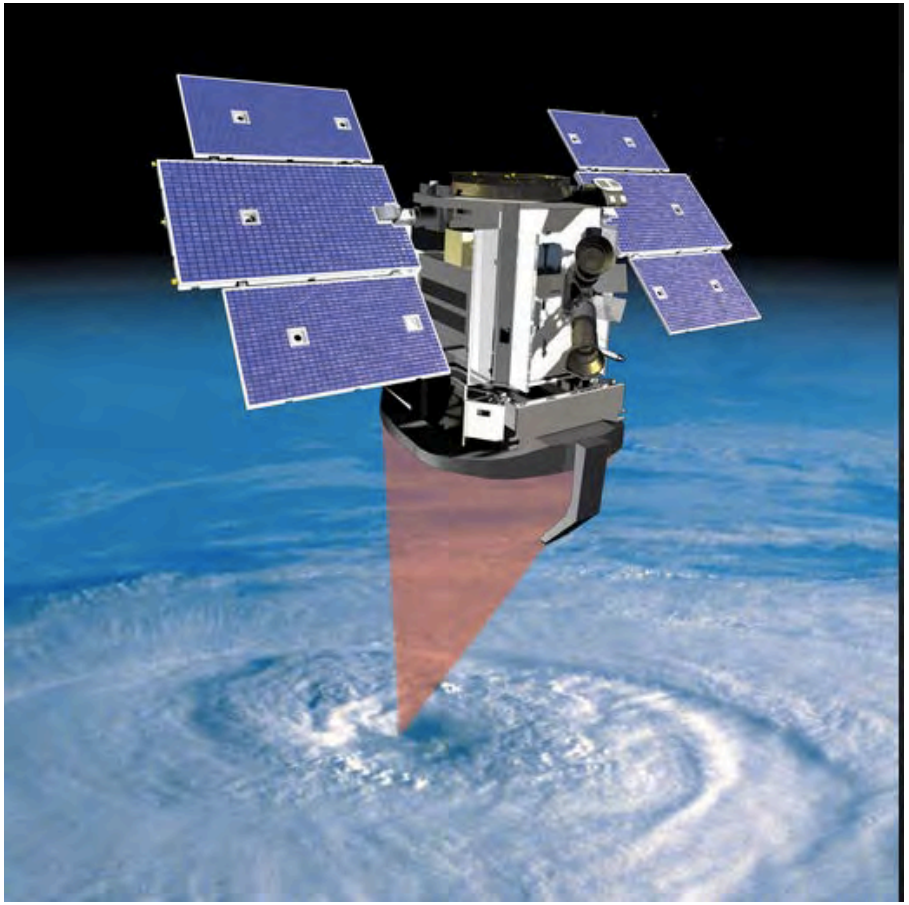
MSS-Iridium 1998 and 2019



2004

Cloudsat

94.05 GHz kW nadir-pointing* cloud radar



And Its Evil Twin

"active denial systems"

***When not gyrating wildly out of control**

Developed in Tucson near the KP12m telescope

9.2-10.4 GHz Synthetic Aperture Radar

ICEYE

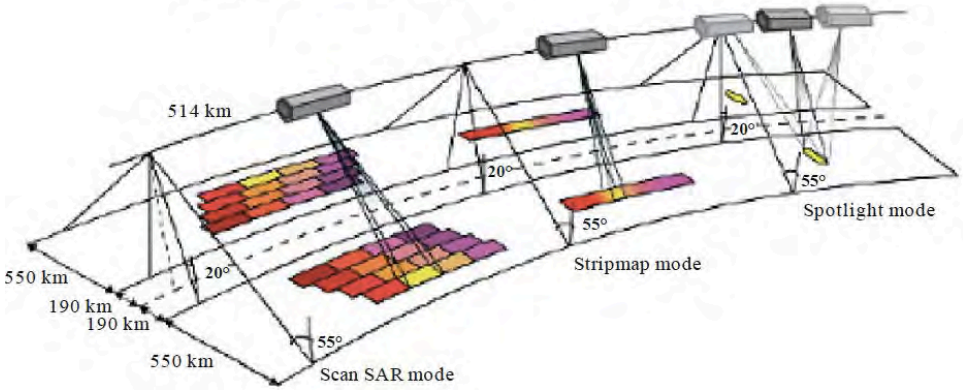
EVERY SQUARE METER,
EVERY HOUR

Commercial startups are launching fleets of dozens

CAPELLA SPACE CORPORATION
DENALI
VAFD – Falcon 9

FIGURE 1

Modes of operations for SAR system in the 9 GHz EESS allocation



9.2-10.4 GHz Synthetic Aperture Radar

Recommendation ITU-R RS.2066-0

(12/2014)

Protection of the radio astronomy service in the frequency band 10.6-10.7 GHz from unwanted emissions of synthetic aperture radars operating in the Earth exploration-satellite service (active) around 9 600 MHz

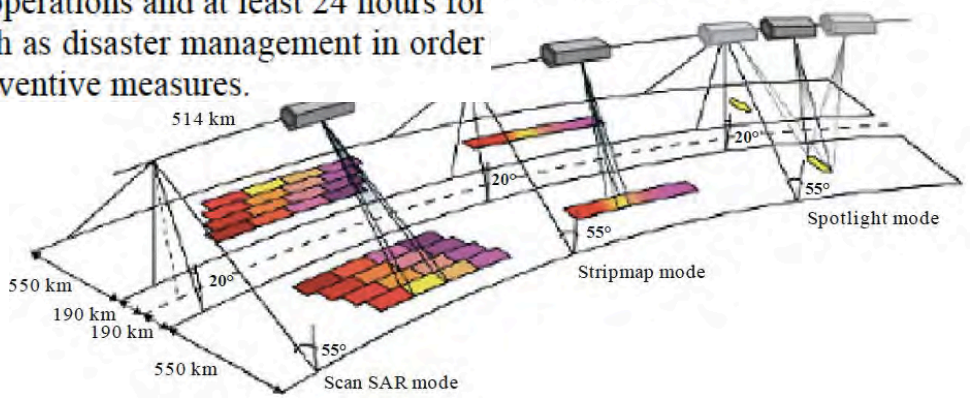
recommends

1 that, in order to ensure compatibility of EESS SAR with RAS stations, EESS SAR systems operating around 9 600 MHz should avoid, to the maximum possible extent, to illuminate an area around radio astronomy stations. The size of such an area is defined in Annex 1. Annex 2 provides the list of RAS stations capable to operate in the frequency band 10.6-10.7 GHz and which may perform observations during times of illumination;

2 that, in the event that the conditions referred to in *recommends* **1** are not met, the operator of the EESS SAR system should contact the operator of the concerned radio astronomy station at least seven calendar days before an event for EESS SAR routine operations and at least 24 hours for EESS SAR acquisition of images in cases of emergency only such as disaster management in order to coordinate and, if necessary, to agree on mitigation or other preventive measures.

RE 1

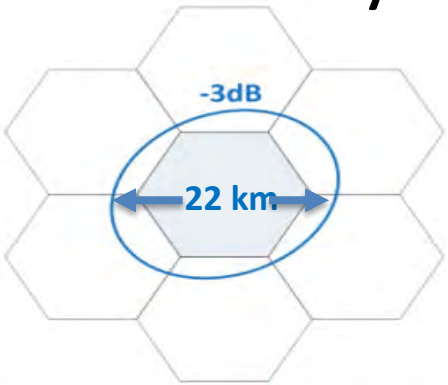
em in the 9 GHz EESS allocation



MSS: Starlink and OneWeb: The Ballad of US131

US131 In the band 10.7-11.7 GHz, non-geostationary satellite orbit licensees in the fixed-satellite service (space-to-Earth), prior to commencing operations, shall coordinate with the following radio astronomy observatories to achieve a mutually acceptable agreement regarding the protection of the radio telescope facilities operating in the band 10.6-10.7 GHz: [12 AUI sites + Arecibo]

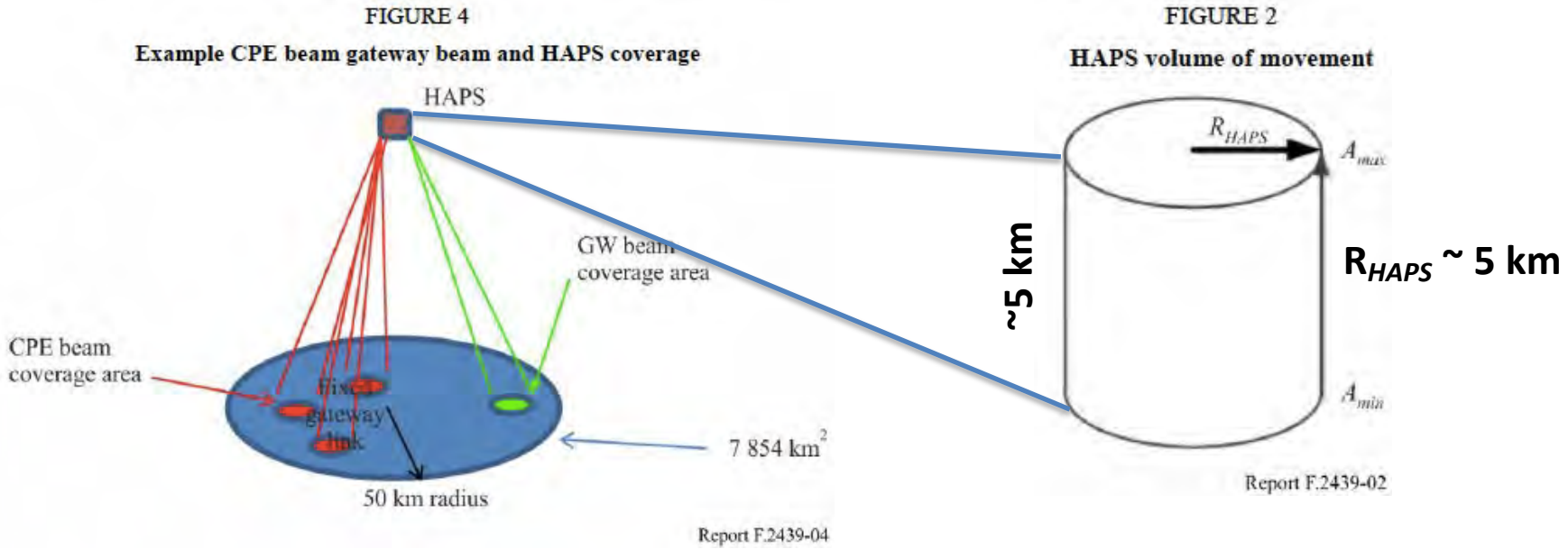
- SpaceX & OneWeb agreed to forgo use of their lowest 250 MHz channel, 1/8 of the allocation
- Compliance depends on knowing things that don't always work as predicted on-orbit



Boys and girls, do you know what HAPS are?

High Altitude Platform Systems

Report ITU-R F.2439-0
(11/2018)



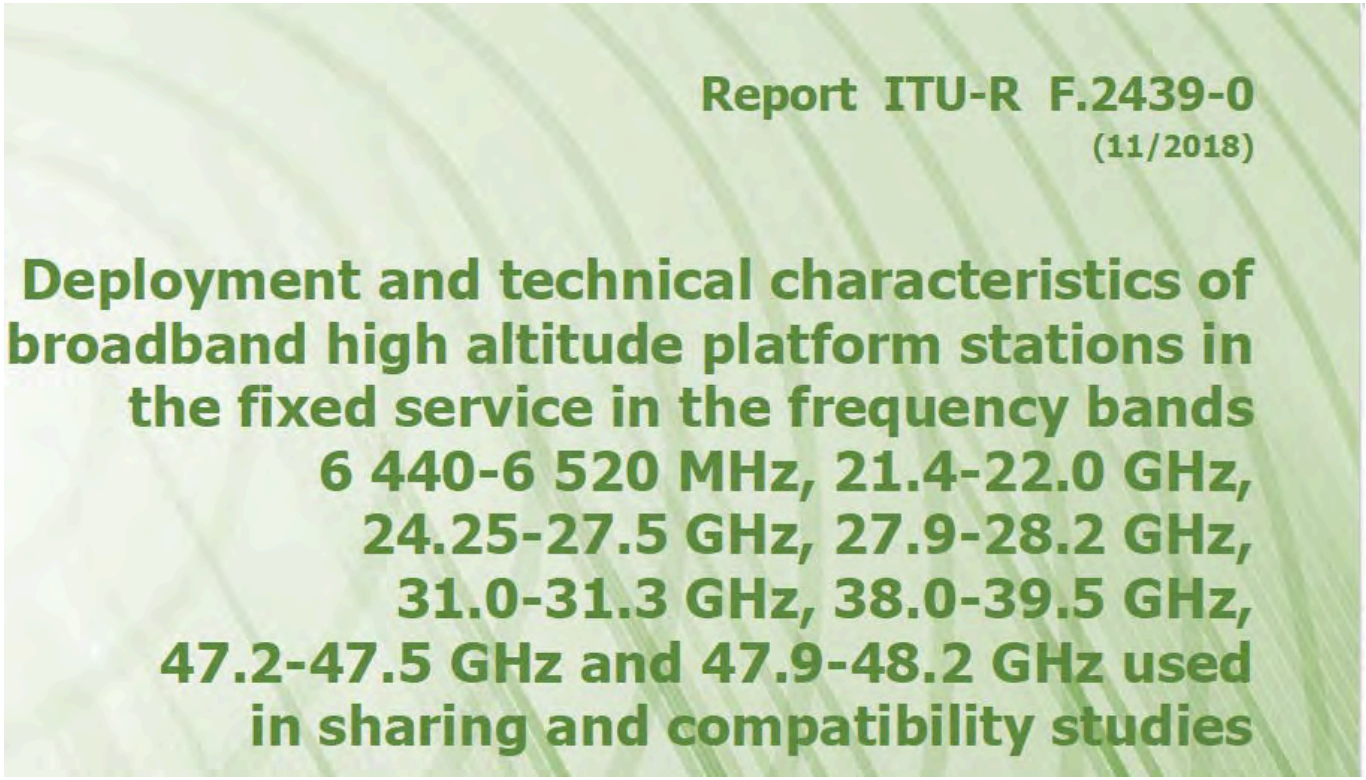
R_{HAPS} ~ 5 km

A platform at 20 km is visible for 510 km at sea level and a full buildout of HAPS would put 81 platforms above the horizon at sea level

An RAS antenna near the edge of a HAPS service area, pointed at the HAPS platform, will burn out the receiver if the HAPS emissions are not filtered out

High Altitude Platform Stations - HAPS

AI 1.14 at WRC-19



HAPS use FS frequencies, but from 20 km altitude

5G Base stations may co-locate on HAPS as HIBS

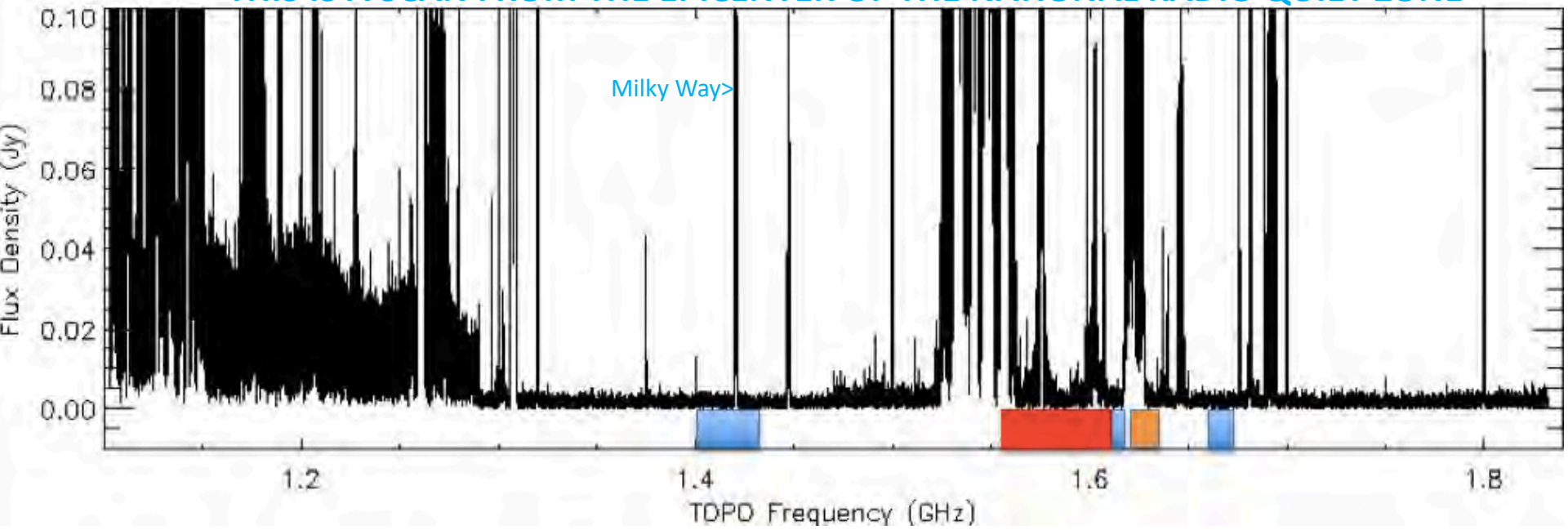
What must RAS do?

- Protect the allocated bands
- Find enough clean spectrum to operate
- Observe with strong emission nearby in passband

What must RAS do?

- Protect the allocated bands
- Find enough clean spectrum to operate
- Observe with incredibly **strong** rapidly **time-varying** emission nearby

THIS IS A SCAN FROM THE EPICENTER OF THE NATIONAL RADIO QUIET ZONE



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High instantaneous spectral and temporal dynamic range will be key

What must RAS do?

- Protect the allocated bands
- Find enough clean spectrum to operate
  - Locate where clean spectrum can be expected
    - Essential to be in a radio quiet zone so frequencies used only on the ground can be kept at a distance
      - Distinction between ground, air & spaceborne use is blurring
      - frequencies formerly used on ground will be used in the air

What must RAS do?

- Protect the allocated bands
- Find enough clean spectrum to operate
  - Locate where clean spectrum can be expected
  - Software/hardware filtering … nulling … seeing-thru interference … temporal coordination …

What must RAS do?

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What must RAS do?

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  - Encroachment by unwanted emissions

What must RAS do?

- Protect the allocated bands
  - Encroachment by unwanted emissions
    - At WRC-19, US advocated 5G unwanted emission limits ~25 dB too high to allow weather forecast satellites to operatr at 24 GHz
    - Settled for 15-20 dB too high
    - Could roll back 30 years of advances in weather forecasting

DECEMBER 10, 2019

CHAIRWOMAN JOHNSON AND RANKING MEMBER LUCAS REQUEST GAO EVALUATION ON SPECTRUM INTERFERENCE ISSUES

Profound imbalance and lack of respect for scientific use of the radio spectrum in domestic decision-making

What must we do?

- Scientific access to spectrum is eroding
- Science does not have a full place at the table
- Scientific use of the spectrum requires higher-level advocacy than what occurs now in the US
  - There should be an obligation to weigh protection of scientific access in spectrum decisions

Thank you

5th International IUCAF Spectrum Management School for Radio Astronomy
Stellenbosch, South Africa 2 – 6 March 2020
www.iucaf.org