Radio Astronomy in a New Era of Satellite Radiocommunication

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&

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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 WARC-59 in Geneva (1400-1427 MHz)
    • 1st passive band, it & others now used for climate study

  – Ah-ha moments for radio astronomy when GPS, GLONASS, Iridium, and CloudSat radar launched
RNSS

GLONASS 1992, 8 yrs after 1st launch

Things were bad but improving with GPS
MSS-Iridium 1998 and 2019

Where they need to be

Interference observed in GB in 1998 w/ no voice traffic

Where they seem to be in 2019

Where they need to be
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

AAS 235 Honolulu 8 January 2020
9.2-10.4 GHz Synthetic Aperture Radar

Commercial startups are launching fleets of dozens.
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

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.
MSS: Starlink and OneWeb: The Ballad of US131

• 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?

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 I.14 at WRC-19

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

Deployment and technical characteristics of broadband high altitude platform stations in the fixed service in the frequency bands 6 440-6 520 MHz, 21.4-22.0 GHz, 24.25-27.5 GHz, 27.9-28.2 GHz, 31.0-31.3 GHz, 38.0-39.5 GHz, 47.2-47.5 GHz and 47.9-48.2 GHz used in sharing and compatibility studies.

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
What must RAS do?

• Protect the allocated bands
• Find enough clean spectrum to operate

• Observe with incredibly strong rapidly time-varying emission nearby

High instantaneous spectral and temporal dynamic range will be key
AAS 235 Honolulu 8 January 2020
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?

• Protect the allocated bands
What must RAS do?

• Protect the allocated bands
  – 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 operate at 24 GHz
    - Settled for 15-20 dB too high
    - Could roll back 30 years of advances in weather forecasting

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