Starlink, Radio Astronomy, Satellites and all that

Harvey Liszt, NRAO

Chair, IUCAF

Radio spectrum use is heavily regulated, optical not so much

- Called spectrum management, the base level of spectrum access
  - Radio spectrum defined as $\lambda \geq 100\mu$, $\nu \leq 3\ 000$ GHz
  - Radio scientists have a >60-year history of training for this

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

SCIENTIFIC COMMITTEE
ON
FREQUENCY ALLOCATIONS
IUCAF FOR
RADIO ASTRONOMY
AND
SPACE SCIENCE

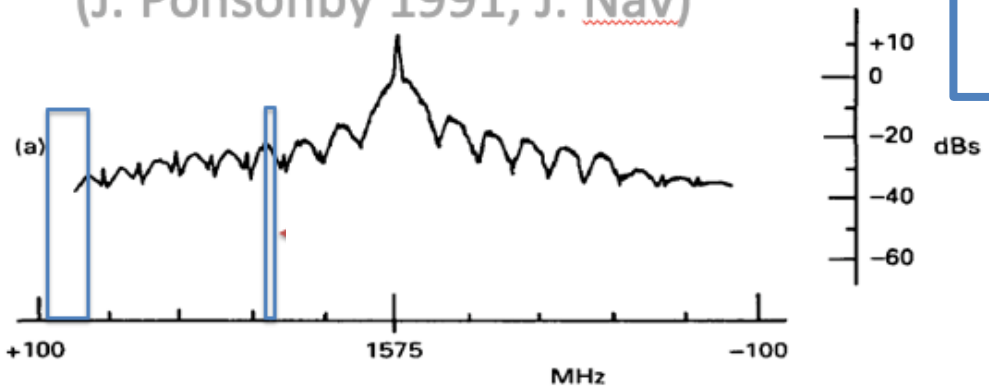
Radio spectrum use is heavily regulated, optical not so much

- Ironically, use of optical spectrum is being impaired by indifferent radio spectrum operators and regulators
- Regulated or not, the endpoint is the same: Scientific access to OIR* spectrum is eroding across wavebands and disciplines

***OIR=Optical, Infrared, Radio**

GPS Block I 1978 -1992

(J. Ponsonby 1991, J. Nav)

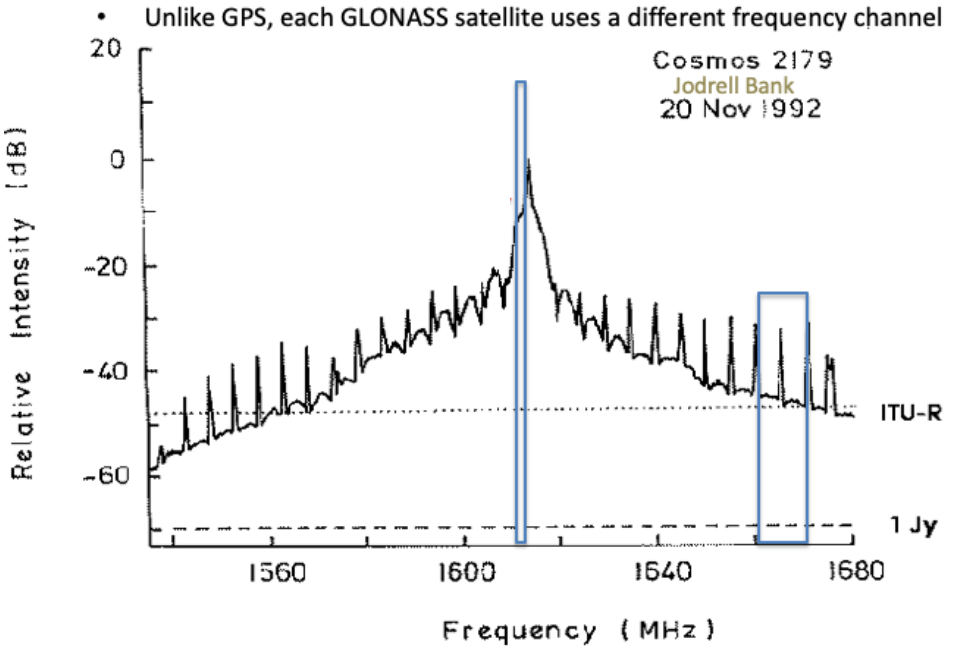


Early RNSS used unfiltered BPSK digital modulation and broadcast unnecessarily over hundreds of MHZ

Radio astronomy allocations are shown as blue rectangles

Radio astronomers have been dealing with satellite interference since the first GPS launch in 1978 and GLONASS in 1984

1984 RNSS-GLONASS 2007



Iridium has interfered at 1612 MHz for 20+ years across two generations of satellites and one huge bankruptcy

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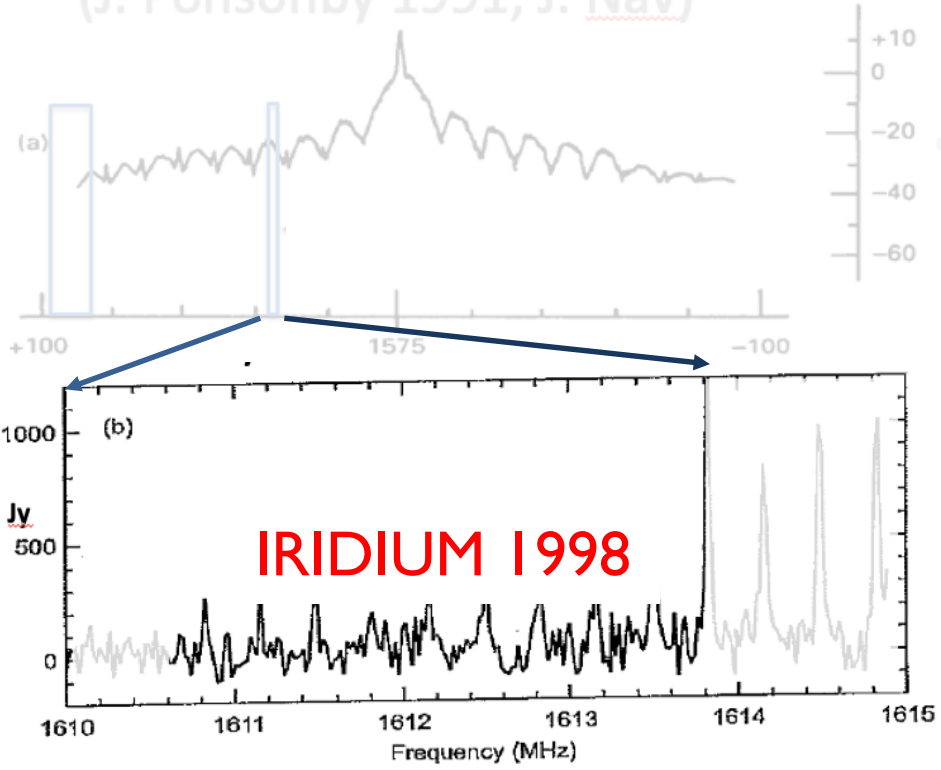

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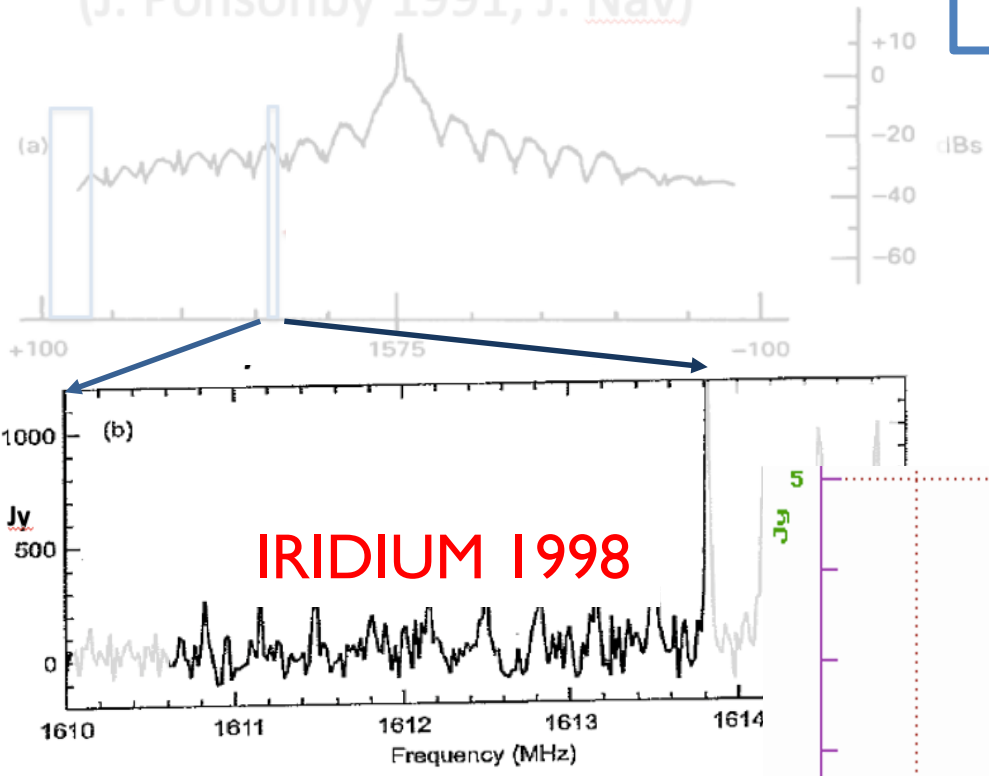
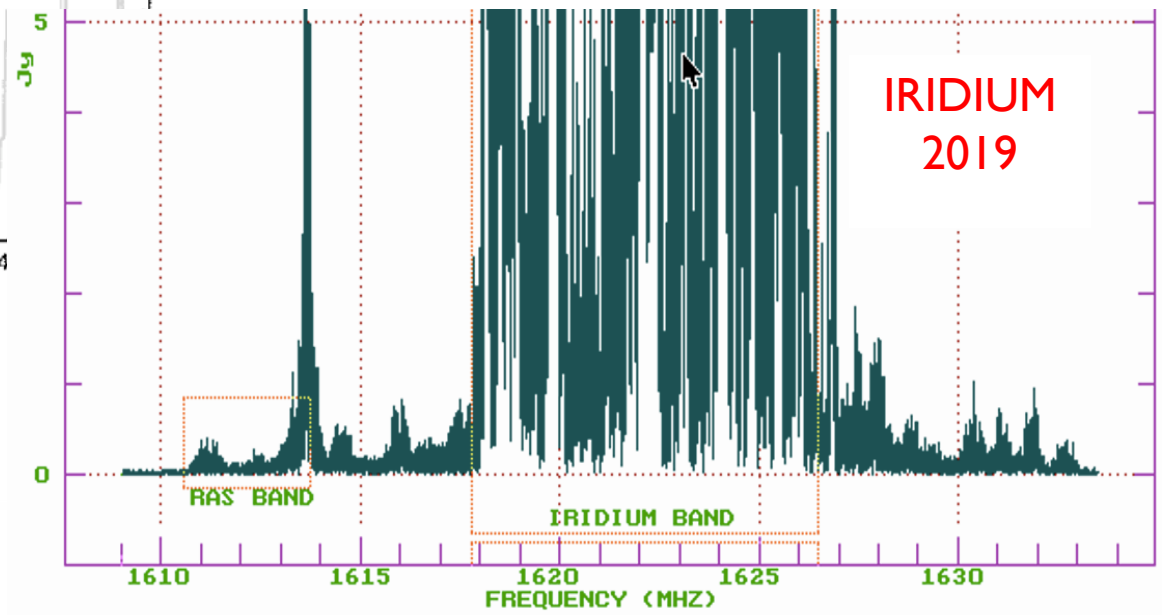


IRIDIUM 1998



IRIDIUM 2019

Why are we here?

- Starlink and other new systems are prodigious spectrum users

ECC Report 271

Table 19: Frequency Bands Used by the SpaceX System

Type of Link and Transmission Direction	Frequency Ranges	RAS band affected
User Downlink Satellite-to-User Terminal	10.7–12.7 GHz	10.6–10.7 GHz (10.68-10.7 passive)
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SpaceX, OneWeb

Use of the 10.7 - 12.7 GHz downlink band is subject to coordination

SpaceX and OneWeb had to agree to forgo use of the lowest 1/8th (250 MHz) of the downlink band

Why are we here?

- spectrum users

The New York Times

SoftBank-Backed OneWeb Files for Chapter 11 Bankruptcy Plan, Cuts Jobs

By Reuters

March 27, 2020

Hi Harvey,

Still OK here in Brittany where the situation is not yet so terrible compare to Paris or the East of France. But it could change.

For ONEWEB I just got the confirmation from them. 90% of employees are fired and the rest will be in a few months.

Regards,

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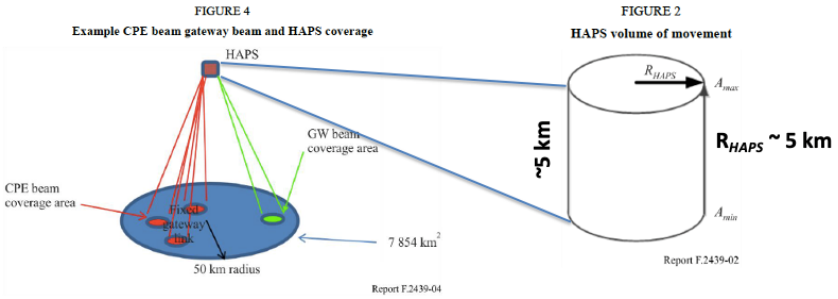

HAPS

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

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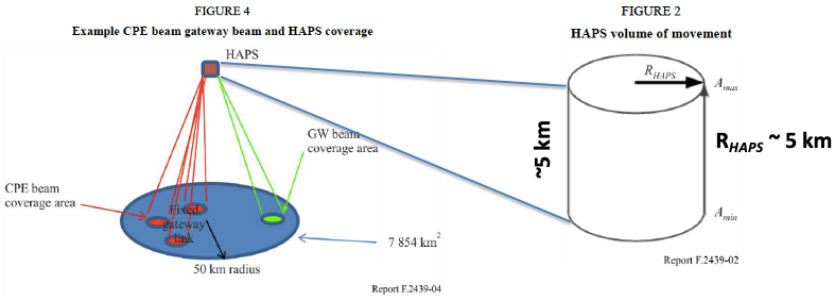

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HAPS proponents also agreed to make substantial sacrifices but their presence would greatly complicate operations for radio telescopes within los, ~ 500 km

Why are we here?

- To say nothing of 5G

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WRC-23:

1.2 to consider identification of the frequency bands

– **3 600-3 800 MHz and 3 300-3 400 MHz** (Region 2);
– **3 300-3 400 MHz** (amend footnote in Region 1);
– **7 025-7 125 MHz** (globally);
– **6 425-7 025 MHz** (Region 1);
– **10 000-10 500 MHz** (Region 2),

- *5G at WRC-15*
  - ***450-470,1427-1452,1492-1518,1710-1885,1885-2025,2110-2200, 300-2400,2500-2690,3400-3600 MHz***

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Why are we here?

- Access to spectrum is eroding for all of science

Why are we here?

- Access to spectrum is eroding for all of science
  - **Only a tiny fraction of the spectrum is *dedicated* to science**
    - **1-2% below 86 GHz, nothing for RAS at 32 - 86 GHz**
  - **More unwanted emissions into dedicated bands**
    - **Lax standards; especially for 5G that is an issue in Congress**
  - **Less unoccupied spectrum**
    - **Will have to look harder and faster for clean spectrum**
    - **Systems making concessions block huge swaths of spectrum**
  - **Weakening of spectrum protections in dedicated bands**
    - **FCC now allowing transmissions in internationally-protected bands dedicated to science**, especially above 95 GHz
  - **Spectrum allocations formerly terrestrial will be used aloft**
    - **HIBS - 5G base stations on HAPS (WRC-23 AI 1.4)**
    - **Earth stations in motion aboard aircraft, UAV**

Why are we here?

- So what can we do; what are we doing to avoid problems?
  - **Radio quiet zones, remoteness to mitigate RFI a priori**
    - **More than a dozen QZ worldwide, see ITU-R Report RA.2259**
    - **Local coordination zones for specific applications like 5G**
  - **Faster, higher dynamic-range receiving signal chains**
    - **oVLA could not observe 1612 MHz after 1998 in the presence of Iridium (unrelated to RFI), the JVLA can**
  - **Increased coordination with "active" services**
    - **Agreements with satellite operators to avoid RAS sites**
      - **For SAR and cloud radars that have lethal signal levels**
  - **Engagement with spectrum management**
    - **The *sine qua non* of access to spectrum**
    - **Where dangers to RAS operations are first recognized**

“RFI is what happens when spectrum management fails”

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- Radio scientists also deal directly with received RFI
  - Regular RFI meetings have broadened beyond RAS to incorporate remote sensing, happen more frequently

PARTNERS

"RFI is what happens when spectrum management fails"

- But this *also* happens when spectrum management fails:

Tacoma, WA, Dec 2017
3 dead for lack of train control on maiden run of this new train line, operator took a 25 mph curve at 78 mph

Harper's Ferry, WVa Dec 2019
Appalachian trail closed

Thanks for inviting me